1993

Cognitive strategies and pain tolerance in athletes with muscle soreness

Lorette Joan Pen
Ithaca College

COGNITIVE STRATEGIES AND PAIN TOLERANCE IN ATHLETES WITH MUSCLE SORENESS

by

Lorette Joan Pen

An Abstract

of a thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in the Division
of Health, Physical Education,
and Recreation at
Ithaca College

May 1993

Thesis Advisor: Dr. A. Craig Fisher

ABSTRACT

This study examined the effects of cognitive strategies on pain tolerance and performance in athletes with muscle soreness/damage. Female (n = 20) and male (n = 14) athletes volunteered to participate in this study. Muscle soreness/damage was induced in the quadricep and hamstring muscle groups on the Biodex System 2 via eccentric knee flexion and extension at a speed of 90 ^{0}/sec. Intraclass correlation coefficients (R) determined the performance scores to be used in subsequent data analyses. Mixed model ANOVAs, univariate ANOVAs, and post-hoc Tukey analyses revealed significant differences (p < .05) in peak torque (PT), total work (TW), and average power (AP) from Session 1 to Sessions 2 and 3. ANOVAs revealed no significant group differences (p > .05) on the Muscle Soreness Scale (MSS), State Anxiety Test (SAT), and Pre-Perception of Performance Scale (Pre-PPS) in Sessions 2 and 3, and Post-Perception of Performance Scale (Post-PPS) in Session 2. ANOVA revealed a significant difference (p < .05) in the Post-PPS in Session 3 and post-hoc Tukey analyses revealed that the association and dissociation groups differed significantly from the control group. The treatment subjects thus perceived that the strategies had significantly improved their performance when in reality their performance had only improved slightly, but not significantly.

There are positive and negative effects to this illusory efficacy as it relates to sport injury rehabilitation.

COGNITIVE STRATEGIES AND PAIN TOLERANCE IN ATHLETES WITH MUSCLE SORENESS

A Thesis Presented to the Faculty of
the Division of Health, Physical
Education, and Recreation
Ithaca College

In Partial Fulfillment of the
Requirements for the Degree
Master of Science

---

by
Lorette Joan Pen
May 1993

Ithaca College
Division of Health, Physical Education, and Recreation
Ithaca, New York

CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Master of Science Thesis of

Lorette Joan Pen

submitted in partial fulfillment of the requirements for the degree of Master of Science in the Division of Health, Physical Education, and Recreation at Ithaca College has been approved

Thesis Advisor:

Committee Member:

Candidate:

Chairman, Graduate Programs in Physical Education:

Dean of Graduate Studies:

Date: 5/10/93

ACKNOWLEDGMENTS

The investigator would like to take this opportunity to express appreciation to the following people for their contribution to this effort:

Dr. A. Craig Fisher, thesis advisor, for spending countless hours with me, giving sound advice, sharing his valuable knowledge, proofreading, editing, and never laughing at the ridiculousness of my questions or requests.

Dr. Gary Sforzo, second reader, for his valuable comments and for giving me a job so I could stay and finish.

Dr. Beth McManis, measurement expert, for all of her time, work, and appreciated advice on my data analysis.

My family and friends in Australia for all their love and support.

Marie Labriola, for being a great friend and support.

The Labriola family in Highland, NY, for "adopting" me.

Paul Touey, graduate colleague, for his friendship.

DEDICATION

This thesis is dedicated to my family and Jill, Steve, and all my other friends who encouraged and supported my ambition to pursue this degree in the United States of America.

TABLE OF CONTENTS

Page

ACKNOWLEDGMENTS ii

DEDICATION iii

LIST OF TABLES vii

LIST OF FIGURES x

CHAPTER

1. INTRODUCTION

Scope of Problem 7

Statement of Problem 9

Hypotheses 9

Assumptions of Study 10

Definition of Terms 11

Delimitations of Study 13

Limitations of Study 13

2. REVIEW OF LITERATURE 15

Pain and its Relevance to
Injury and Performance 16

Acute and Chronic Pain 22

Sport Injury Related Pain 23

Cognitive Strategies and Pain Tolerance . . 25

Limitations to Experimentally Induced Pain . 34

Summary 38

TABLE OF CONTENTS (continued)

CHAPTER Page

3. METHODS AND PROCEDURES 42
   Selection of Subjects 42
   Testing Instruments 42
   Testing Procedures 43
   Treatment of Data 50
   Summary 51
4. ANALYSIS OF DATA 53
   Description of Subjects 53
   Internal Consistency of Performance Data . . 54
   Analyses of the Performance Variables, PT, TW, and AP 58
   Analysis of SAT and Pre-PPS (Sessions 2 and 3) 82
   Comparison of the MSS, Pre-PPS, and Post-PPS Groups for PT, TW, and AP over the Three Testing Sessions 85
   Analyses of the MSS, Pre-PPS, and Post-PPS in Session 3 87
   Analysis of SEQ Item Responses 89
   Summary 96

TABLE OF CONTENTS (continued)

CHAPTER	Page
5. DISCUSSION OF RESULTS	99
Effectiveness of Soreness Induction Procedure as a Pain Model	100
Effectiveness of Cognitive Strategies . . .	102
Appropriateness of Cognitive Strategies in Rehabilitation	112
Summary	115
6. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS .	119
Summary	119
Conclusions	121
Recommendations	122
APPENDIXES	
A. INFORMED CONSENT FORM	123
B. MEDICAL HISTORY QUESTIONNAIRE	127
C. STATE ANXIETY TEST	131
D. PRE-PERCEPTION OF PERFORMANCE SCALE . . .	132
E. MUSCLE SORENESS SCALE	133
F. POST-PERCEPTION OF PERFORMANCE SCALE . .	134
G. STRATEGY EVALUATION QUESTIONNAIRE . . .	135
H. DEBRIEFING STATEMENT	137
I. STRATEGY DIALOGUES	138

TABLE OF CONTENTS (continued)

	Page
REFERENCES	144

LIST OF TABLES

Table Page

1. Intraclass Correlation Coefficients for Peak Torque (PT), Total Work (TW), and Average Power (AP) 55
2. Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Hamstrings at 10 repetitions . 59
3. Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Quadriceps at 10 repetitions . 64
4. Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Hamstrings at 40 repetitions . 71
5. Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Quadriceps at 40 repetitions . 77
6. Mean Scores of Muscle Soreness Scale (MSS), Pre-Perception of Performance Scale (Pre-PPS), and Post-Perception of Performance Scale (Post-PPS) in Sessions 2 and 3 84
7. Analysis of Strategy Evaluation Questionnaire (SEQ) Item Responses by Group 90

LIST OF TABLES (continued)

Table Page

8. Predominant Thoughts During Testing by Group . . . 93

LIST OF FIGURES

Figure Page

1. Means for peak torque of the hamstrings at 10 repetitions 61
2. Means for total work of the hamstrings at 10 repetitions 62
3. Means for average power of the hamstrings at 10 repetitions 66
4. Means for peak torque of the quadriceps at 10 repetitions 67
5. Means for total work of the quadriceps at 10 repetitions 68
6. Means for average power of the quadriceps at 10 repetitions 69
7. Means for peak torque of the hamstrings at 40 repetitions 73
8. Means for total work of the hamstrings at 40 repetitions 74
9. Means for average power of the hamstrings at 40 repetitions 75
10. Means for peak torque of the quadriceps at 40 repetitions 79

LIST OF FIGURES (continued)

Figure Page

11. Means for total work of the quadriceps at 40 repetitions 80

12. Means for average power of the quadriceps at 10 repetitions 81

13. Pre-perception of performance (Pre-PPS) and post-perception of performance (Post-PPS) scores in session 3 88

Chapter 1

INTRODUCTION

All athletes will experience pain through injury at some time in their careers (Gauron & Bowers, 1986). Pain and the associated discomfort are characteristic of most sport injury rehabilitation regimens and have the capacity to interrupt or terminate treatment (Fisher & Hoisington, 1993). In general, the focus of sport injury rehabilitation is to return injured athletes to performing again at their full potential (Domm, 1985). However, one major barrier to sport injury rehabilitation is pain. Athletes differ in their ability to function and cope with pain following injury (Gauron & Bowers, 1986), and, accordingly, it would appear that some athletes are able to adhere to their rehabilitation program while others are not. Pain tolerance levels vary from athlete to athlete and from individual to individual. Those with a lower pain tolerance level are obviously able to tolerate less pain than those with a higher level of pain tolerance. Thus, being able to manage the level of pain experienced can be central to successfully completing a rehabilitation program. Often, it is the injured athletes' ability to tolerate their level of pain that may determine the speed of their recovery.

Pain tolerance is closely linked with the perception that pain has occurred, or should occur. There are many varied reactions to the pain experience. These reactions range from the extremes of not noticing that an injury has occurred to excruciating pain associated with what is actually a trivial injury (Melzack, 1973). How does one account for these extreme reactions? When a sufficient amount of intense, prolonged attention is endured, it is possible that other stimuli (e.g., injury that normally causes considerable pain) can go unnoticed. For example, consider athletes who have competed in a very close and, therefore, tense competition that requires total concentration. Some of these athletes will often notice for the first time pain in an injured body part at the end of the game and, therefore, less attention is available for thinking, or even realizing, about pain (McCall & Malott, 1984). They may have no recall of when or how the injury occurred because all of their attention was focused on the competition. Alternatively, when there is little attention required, other stimuli can be heightened (e.g., injury that normally causes little pain but becomes excruciating as all attention is focused on this experience) (Melzack, 1973). Athletes' attitudes towards pain and the cognitive strategies that they use while experiencing pain can influence not only their pain tolerance levels but also their performance and adherence to their sport injury rehabilitation regimen (Meyers, Bourgeois, Stewart, & LeUnes, 1992). Thus, the ability to tolerate pain and minimize the effect pain has on performance may be a useful aid to sport injury rehabilitation.

Whereas pain is consciously perceived at approximately the same physiological level (e.g., tissue damage), pain tolerance levels can be strongly influenced by psychological and/or environmental cues (Anshel, 1990; Ryan & Kovacic, 1966; Scott & Gijsbers, 1981; Spink, 1988). The causes, types, and treatments of sport related injury have been extensively covered in the literature. However, there is a dearth of literature that relates to the psychological realm of sport related injury and pain. Any injury that causes either a temporary or permanent impairment to athletes being actively involved in their sport can be psychologically devastating. Severely injured athletes experience strong emotions that are generally negative in nature and range from anxiety, uncertainty, anger, hopelessness, and loss of control (Pedersen, 1986). As normally active athletes must endure long periods of inactivity, rest, and uncertainty surrounding their athletic future, these emotions can have a debilitating effect on the length of time needed in rehabilitation (Weiss & Troxel, 1986). To further compound the strong, devastating emotions that are associated with injury is the actual experience of pain. The pain experience has an unpleasant, affective quality and can become so overwhelming that it will disrupt ongoing behavior and thought (Melzack, 1980). Rehabilitation can be a lengthy process should the injured athlete be unable to effectively deal with the emotions and pain that are associated with injury. One method that has been used to manage the level of pain experienced has been cognitive/psychological strategies (e.g., association and dissociation).

Association and dissociation are two cognitive strategies that have been used to aid individuals cope with pain. These strategies are designed to either help individuals focus attention on the pain (association) or refocus attention away from the pain (dissociation) (Williams & Kinney, 1991). In addition, self-efficacy expectancies, internal or external locus of control, fear of pain, and pain anticipation can all be relevant functions that help explain how individuals cope with their pain experience. These mental components can decrease or affect pain tolerance levels and thereby be detrimental in a rehabilitation program. Cognitive strategies can increase pain tolerance levels because they affect the strong mental component that is involved in pain (Gauron & Bowers, 1986).

By either focusing on the pain or dissociating from the pain, individuals may reduce both the level of pain experienced and the associated discomfort.

Researchers who have investigated cognitive strategies and pain tolerance generally use pain stimuli that are experimentally induced. These pain stimuli have included cold pressor, radiant heat, electric shock, mechanical pressure, and ischemic pain (e.g., Chapman, 1980; Fernandez, 1989; Friedman, Thompson, & Rosen, 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). However, subjects in these studies are aware that the pain stimulus will be terminated at their insistence or when a predetermined level set by the investigator has been reached (Friedman et al., 1985). Even though the results of these studies cannot be directly compared to clinical pain conditions, these studies have provided ideas that are useful for patients in pain (Thorn & Williams, 1989). Obviously, actual pain as a result of injury is one of the most effective tests of pain tolerance and performance.

Strenuous, unaccustomed exercise will produce muscle damage and muscle soreness (Armstrong, 1984; Clarkson, Nosaka, & Braun, 1992; Smith, 1991). Novel or unfamiliar eccentric actions cause soreness to appear 24 hr after exercise and peak at 48-72 hr postexercise. Interestingly, eccentric actions also provide a dramatic isometric strength loss of over 50% immediately after exercise. Strength is slowly, but gradually, restored and generally 10 days after exercise a slight deficit still remains (Clarkson et al., 1984). Thus, strenuous, unaccustomed eccentric exercise will produce muscle soreness and strength loss.

There have been many studies that have investigated the effectiveness of association and dissociation strategies on pain tolerance and performance using traditional methods of pain induction, including cold pressor, radiant heat, electric shock, mechanical pressure, and ischemic pain. The majority of these studies require subjects to withstand the stimulus for as long as possible as a baseline measurement. A cognitive strategy is then implemented, and the length of time that the subject can withstand the pain stimulus is again measured (e.g., Chapman, 1980; Fernandez, 1989; Friedman et al., 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). However, all of these investigations were inherently safe for the subjects as the experiment could be terminated at the subjects' command or when a safe, predetermined level had been reached.

Muscle soreness provides a source of temporary yet potentially intense real life pain. Subjects would experience pain that could not be terminated on command. No previous study has used an experimentally induced pain whose intensity the subject could not control. That is, naturally occurring pain cannot be turned on or off. The purpose of this investigation was to test the effectiveness of association and dissociation cognitive strategies on pain tolerance and performance in athletes with exercise-induced muscle soreness/damage.

Scope of Problem

This study was designed to investigate the effects of two cognitive strategies, association and dissociation, on pain tolerance and performance in athletes with muscle soreness/ damage. The subjects were 18 female and 12 male Ithaca College athletes, and all subjects participated in the three sessions of the study.

Session 1 provided a baseline measurement of hamstring and quadricep muscle group strength and also served to induce muscle soreness/damage in these muscle groups. Subjects were evaluated on a Biodex System 2 (a muscle function testing device) and a protocol of two sets of 10 repetitions of maximal eccentric contractions, two sets of 40 maximal eccentric contractions, and five sets of 10 maximal eccentric contractions followed to induce muscle soreness/damage. To ensure muscle soreness/damage was induced, subjects were also required to perform five sets of 10 repetitions of leg squats at 80% maximal lift until involuntary exhaustion. Specific measurements of performance were taken for the initial two sets of 10 and two sets of 40 repetitions of maximal eccentric contractions. These measurements were used to compare performance in the next two sessions. In Session 1 subjects were also required to complete the Informed Consent Form (ICF) (Appendix A), Medical History Questionnaire (MHQ) (Appendix B), and the State Anxiety Test (SAT) (Appendix C).

Session 2 required the subjects to return 48 hr after Session 1 and complete the SAT, Pre-Perception of Performance Scale (Pre-PPS) (Appendix D), and Muscle Soreness Scale (MSS) (Appendix E) prior to testing. Subjects were then retested on the Biodex System 2 by completing two sets of 10 repetitions and two sets of 40 maximal eccentric contractions to measure power/strength loss due to pain from the delayed onset muscle soreness/damage. Immediately following the testing, subjects completed the Post-Perception of Performance Scale (Post-PPS) (Appendix F).

Session 3 required the subjects to return 3 hr after

Session 2 and complete the SAT, Pre-PPS, and MSS prior to testing. Each subject listened to a prepared tape (i.e, association strategy, dissociation strategy, or control--no strategy) twice and then performed two sets of 10 repetitions of maximal eccentric contractions. Each subject listened to the same prepared tape again and then performed two sets of 40 repetitions of maximal eccentric contractions. After subjects completed the Post-PPS, they completed the Strategy Evaluation Questionnaire (SEQ) (Appendix G) and then were debriefed (Appendix H).

Statement of Problem

This study assessed the impact of two cognitive strategies (association and dissociation) on pain tolerance and performance in athletes with induced muscle soreness/ damage.

Hypotheses

1. Subjects in the association group will significantly increase their performance scores, as measured by peak torque (PT), total work (TW), and average power (AP), from Session 2 to Session 3.

2. Subjects in the dissociation group will significantly increase their performance scores, as measured by PT, TW, and AP, from Session 2 to Session 3.

3. Subjects in the control group will not significantly increase their performance scores, as measured by PT, TW, and AP, from Session 2 to Session 3.

4. Muscle soreness, and not anxiety or pre-perception of performance, will be closely related to the decreased performance scores in Sessions 2 and 3 from Session 1.

5. There will be no group differences on the MSS, Pre-PPS, and Post-PPS in Session 2.

6. Subjects in the association group will show a significant increase in their Post-PPS scores in Session 3 compared to the scores of subjects in the control group, thereby demonstrating a significant increase in their pain tolerance levels.

7. Subjects in the dissociation group will show a significant increase in their Post-PPS scores in Session 3 compared to the scores of the control group, thereby demonstrating a significant increase in their pain tolerance levels.

Assumptions of Study

For the purpose of this study the following assumptions were made:

1. Muscle soreness represented a pain experience comparable to a sport injury related pain.

2. Subjects completed all questionnaires truthfully.

3. The Biodex System 2 was an accurate measure of quadricep and hamstring muscle groups strength.

4. The MSS was an accurate measure of muscle soreness.

5. The Pre-PPS and Post-PPS were accurate measures of perception of performance.

6. The subjects utilized the strategy/instruction outlined on the prepared tapes.

7. All subjects performed a maximal effort in all sessions of the testing.

Definition of Terms

The following terms were defined for the purpose of this study:

1. Association strategy: A cognitive strategy that requires individuals to either focus on bodily sensations or change their appraisal of the pain.

2. Athlete: A college student who had competed for an Ithaca College representative sport team in the last 12 months.

3. Average power: The total work (force multiplied by distance produced throughout the entire range of motion) divided by the time it takes to perform the work. Power is used to measure muscular efficiency.

4. Biodex System 2: A computerized isokinetic, isometric, isotonic device that measures strength, power, and joint range of motion of selected muscle groups.

5. Dissociation strategy: A cognitive strategy that requires individuals to refocus their attention away from the pain by using either internal or external distractors.

6. Eccentric muscle contraction: Lengthening of a muscle under tension.

7. Pain: An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage.

8. Pain threshold: The point at which the least intense noxious stimulation is consciously perceived as pain by an individual (Bowsher, 1988).

9. Pain tolerance: The point at which individuals experience the greatest intensity of noxious stimulation that they can bear (Bowsher, 1988).

10. Peak torque: The highest vale of torque (a function of force and distance from the axis of rotation) developed throughout the range of motion.

11. Self-efficacy: The strength of one's conviction that one can successfully execute a behavior required to produce a certain outcome (Bandura, 1977).

12. Sport injury rehabilitation: The process by which an injury, sustained through the pursuit of sport, is remediated.

13. Total work: The sum of work for every repetition performed in the set.

Delimitations of Study

The following decisions served as delimitations for this study:

1. Only college athletes were tested.

2. Perceived muscle soreness was assessed by the investigator's test of perceived muscle soreness.

3. Pre-perception of performance was assessed by the investigator's test of perception of performance.

4. Post-perception of performance was assessed by the investigator's test of perception of performance.

5. Subjects were only exposed to the cognitive strategies during the final session of testing.

Limitations of Study

The following decisions served as limitations for this study:

1. The results may only be generalized to populations who are considered similar to the subjects in this study.

2. Perceived muscle soreness was assessed only within the confines of the test used.

3. Pre-perception and post-perception of performance were assessed only within the confines of the tests used.

4. The results may only apply to individuals who have similar exposure time to cognitive strategies prior to testing.

Chapter 2

REVIEW OF LITERATURE

Pain is an integral part of the human condition and is an experience that virtually all athletes will face (Gauron & Bowers, 1986). Each year, approximately 3 to 5 million injuries occur in the context of recreational physical activities and competitive athletics (Kraus & Conroy, 1984). Thus, one unpleasant aspect of sport competition is sustaining an injury and enduring the accompanying discomfort (Anshel, 1990). Any physical impairment that prohibits athletes from being actively involved with their sport, whether temporary or permanent, is cognitively, emotionally, and behaviorally challenging (Pedersen, 1986). There has been a considerable amount of literature conducted concerning the physical causes, types, and treatments of sport related injuries. However, there is a dearth of literature relating to the ability of athletes to tolerate and cope with the pain they experience when injured. Pain also represents a barrier to sport injury rehabilitation. Those involved in rehabilitating sports injuries should be aware of the effectiveness of cognitive strategies that might assist athletes overcome the pain of rehabilitation (Fisher, Domm, & Wuest, 1988).

This chapter is divided into the following subheadings: (a) pain and its relevance to injury and performance, (b) acute and chronic pain, (c) sport injury related pain, (d) cognitive strategies and pain tolerance, (e) limitations to experimentally induced pain, and (f) summary.

Pain and its Relevance to Injury and Performance

The study of clinical pain can be problematic because the intensity and precise features of the nociceptor (i.e., receptor of pain stimuli) remain unknown (Fernandez, 1989). Since the early experiments by von Frey in 1897, several standardized techniques that allow the induction of pain using clearly defined stimuli under highly controlled conditions have emerged for the experimental induction and measurement of pain. These stimuli include radiant heat, cold pressor, electric shock, mechanical pressure, and ischemic pain (through application and inflation of a sphygmomanometer cuff and/or use of a grip strength dynamometer). There have been numerous studies that have investigated the effects of these diverse pain stimuli under a variety of conditions (e.g., Chapman, 1980; Fernandez, 1989; Friedman et al., 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989).

Many of the studies that incorporated these pain induction techniques were undertaken to test cognitive strategies designed to increase pain perception threshold (strictly defined as the least intensity of noxious stimulation at which an individual consciously perceives pain) and pain tolerance level (strictly defined as the greatest intensity of noxious stimulation an individual can bear). However, one limitation of these laboratory studies is that they often fail to mimic the dominant factor in many medical settings--pain or the likelihood of pain--both of which can induce fear or feelings of perceived threat (Friedman et al., 1985). Fear or perceived threat can in turn decrease an individual's level of pain threshold and pain tolerance and, thus, adversely affect performance.

One of the major problems with pain is that responses to it are so varied. Sometimes pain fails to occur when extensive areas of the body have been seriously injured; at other times pain persists after all the injured tissues have healed (Melzack, 1973). Sometimes pain can be experienced in a body part that has been amputated (phantom pain syndrome), and sometimes pain can be excruciating when a minor injury has occurred. These varied and extreme responses to pain are due largely to the individual's ability to cope with the pain stimulus because a stimulus that evokes pain in one individual might easily be tolerated by another. Therefore, pain is a highly complex and personal phenomenon that differs from individual to individual.

Pain has sensory qualities along with emotional and motivational properties (Melzack, 1973). The sensory input that triggers pain is often referred to as noxious stimulation. However, there is little neurological evidence of noxious stimulation; each stimulus only generates a wave of energy that travels along a certain neural pathway. What makes these volleys of stimuli noxious is how a person perceives and recognizes them (Brena, 1972). Pain can thus be thought of as a psychic or cortical phenomenon. Technically it does not exist unless, and until, the cerebral cortex receives information that evokes pain. Therefore, pain can be defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Bogduk, 1991).

The pain experience has a distinctly unpleasant, affective quality. It can become overwhelming, demand immediate attention, disrupt ongoing behavior and thought, and motivate individuals into activity aimed at stopping it as quickly as possible (Melzack, 1980). Pain is a pervasive form of human suffering because its behavioral sequelae can include needless disruptions of functional coping behavior. Therefore, every individual must be able to tolerate pain to some extent and function effectively despite it (Williams & Kinney, 1991). The ability to tolerate pain is largely dependent on how an individual perceives the pain experience.

It is not beyond the realm of common sense to assume that each individual is living in a world that is unique to that individual alone (Ryan, 1976). The brain maintains a moment-to-moment awareness of both the body and the surrounding physical environment. With each new stimulus the brain takes notice, organizes, interprets, and then evaluates each stimulus. This ongoing process of awareness is termed perception, and the pain experience is one aspect of perception (Chapman, 1980). The varied reactions to the pain experience can largely be explained by the individual's anxiety level, the attitude of the injured individual, how the individual perceives the injury, and the individual's reaction to the injury, rather than the actual extent of tissue damage (Beecher, 1956). Almost any situation that attracts a sufficient degree of intense, prolonged attention may provide the conditions for other stimuli to go unnoticed, including injury that would normally cause considerable pain (Melzack, 1973). Consider, for example, the athlete who sustains an injury during the excitement of a close game but does not realize the injury has occurred until the game has ended. Medical personnel attending to athletic injuries observe considerable variation among athletes in response to an injury, which is not explained by the seriousness of the injury (Crossman & Jamieson, 1985).

In the area of sport injury rehabilitation adherence, Fisher et al. (1988) found that adherents to their rehabilitation regimen tolerated pain and discomfort better than nonadherents. The authors surmised that, possibly, adherents may be able to reduce pain, whereas nonadherents may actually increase pain. Fisher, Mullins, and Frye (1993) found, from the clinicians' point of view, that athletic trainers felt that an important index of rehabilitation adherence was the injured athlete coming to grips with the likelihood of pain. Interestingly, in a follow up study, Fisher and Hoisington (1993) found that athletes reported pain to be less a deterrent to rehabilitation program adherence than the athletic trainers had reported. It appears that both athletic trainers and athletes agree, albeit to different extents, that the accurate appraisal of pain and the subsequent focusing of attention (e.g., association or dissociation) are important factors in maintaining rehabilitation adherence (Fisher et al., 1993). Thus, cognitive strategies aimed at increasing pain tolerance may assist those athletes who drop out of sport rehabilitation programs due to a low pain tolerance level. Generally, these athletes stop adhering to their rehabilitation program because they believe they cannot tolerate the pain experienced, and/or their anticipation of additional pain causes them to terminate the program.

Research has indicated that certain athletes have the ability to withstand pain, allowing them to successfully perform in their sport. Ryan and Kovacic (1966) revealed that there was no difference in the pain thresholds of three groups: contact athletes, noncontact athletes, and nonathletes. However, they did find that athletes in contact sports were able to tolerate significantly more pain than nonathletes and athletes in noncontact sports. Similarly, Scott and Gijsbers (1981) found that competitive swimmers had a significantly higher tolerance of ischemic pain than did a comparable group of club swimmers and a group of noncompetitive athletes. Thus, it would appear that pain is consciously perceived at approximately the same physiological level, regardless of the type of sport or the standard of athlete. However, pain tolerance seems to be more dependent on the psychological or environmental factors that are present (Anshel, 1990).

Acute and Chronic Pain

When medical and related professions speak of pain experiences, they generally refer to one of two categories--acute pain and chronic pain. Acute pain is short-term pain and is usually associated with a well-defined cause, such as a bang on the elbow or a cut (Bresler, 1977). Acute pain usually arises after a sudden trauma, then persists for a variable, short period of time, and, once recovered, does not usually reoccur (Melzack & Dennis, 1978).

Chronic pain is unlike acute pain in that it is generally not caused by a sudden trauma, it will persist for long periods of time, and it will reoccur (Bresler, 1977). Arthritis and persistent back pain are typical examples of chronic pain. Melzack and Dennis (1978) stated that chronic pain may also spread to adjacent or more distant body areas and is characteristically associated with high levels of anxiety and depression. This anxiety and depression usually results from feelings of helplessness and lack of self-control of the pain experience.

Therefore, one could surmise that pain can be neatly compartmentalized into the two categories of acute and chronic pain. However, this does not take into account the strong mental and/or psychological component that is involved in pain. Pain experienced in the total absence of noxious stimulation is termed psychogenic pain and it complicates our understanding of pain. Psychogenic pain has no apparent cause but is perceived by the individual as acute or chronic. For example, Bayer, Baer, and Early (1991) found that half of the subjects who were connected to a sham stimulator and told that a headache would occur as a result of the electric current they would receive reported pain. The authors surmised that the reported pain was strongly influenced by environmental cues. Similarly, phantom limb pain can be experienced by amputees in their amputated body part. Despite the absence of the body part, amputees can still perceive the pain that they believe should be experienced due to the seriousness of the injury that necessitated the amputation. Phantom limb pain can therefore be attributed to psychological cues that the amputee processes. Thus, psychogenic pain and phantom limb pain are just two examples of how psychological and/or environmental cues can influence pain perception and tolerance.

Sport Injury Related Pain

The greater percentage of sport injury related pain is caused by sudden onset or trauma. Thus, technically most athletic pain is acute in nature. However, some athletic pain is brought on by repeated stress or overuse, which tends to be more chronic in nature. Often athletes sustain an acute injury that, by Bresler's (1977) definition, would get better by itself after a short time. However, many athletes continue to compete after sustaining these acute injuries and thereby increase their severity. Occasionally, these acute injuries become chronic in nature because of the repeated stresses of activity. These injuries are called chronic by athletic trainers and physical therapists but are not chronic in the strictest definition. However, in the most practical or experimental sense they are chronic to those involved, namely injured athletes and their medical attendants (Hotchkiss, 1981).

The literature on sport injury rehabilitation adherence, albeit sparse, has revealed that severely injured athletes experience a wide gamut of emotions (e.g., Duda, Smart, & Tappe, 1989; Fisher et al., 1988; Fisher, 1990; Fisher & Hoisington, 1993; Lynch, 1988; Pedersen, 1986; Smith, Scott, & Wiese, 1990; Wiese & Weiss, 1987). Some of the strongest and most devastating emotions are usually associated with a debilitating injury, one that requires the normally active participant to endure long periods of inactivity, rest, and uncertainties surrounding future competition (Weiss & Troxel, 1986). On the cognitive level, the athlete must understand the nature of the injury, treatment protocol, and prognosis for recovery. Emotionally, feelings such as anxiety, uncertainty, blame, guilt, anger, hopelessness, loss of control, and the athletes' perception of pain and their apprehension of the onset of pain that may be a part of their treatment regimen must be worked through (Pedersen, 1986). A certain magnitude of pain might cause an interruption or even cessation of the rehabilitation program (Fisher et al., 1993). Should athletes concentrate on emotion-focused coping techniques, rather than problem-focused coping techniques, their healing may be delayed and their pain exacerbated (Smith et al., 1990).

Cognitive Strategies and Pain Tolerance

Cognitive methods can reduce pain and help the individual cope with the associated discomfort because there is a strong mental component in pain (Gauron & Bowers, 1986). A variety of briefly administered psychological treatments for pain have been developed, based on diverse theoretical conceptions of pain. These psychological treatments attempt to help patients deal with pain in a number of situations. Acutely painful therapeutic procedures may require briefly administered pain-coping strategies because lengthy psychological interventions would be either impossible (e.g., in emergencies) or far too time-consuming and expensive (e.g., in routine rehabilitation regimens) (Williams & Kinney, 1991). Cognitive theories generally emphasize the attention and thoughts people deploy toward painful feelings and stimuli. Strategies based on this approach seek to help people refocus attention away from pain (dissociation) or reinterpret or focus attention on the pain (association) (Williams & Kinney, 1991).

Dissociation involves refocusing attention away from the pain and includes distractors that are either internal (e.g., visualizing a pleasant scene, performing mental arithmetic, repeating a selected phrase or word, concentrating on rate of breathing, counting) or external (e.g., concentrating on projected slides, listening to music, watching videos or television) (Williams & Kinney, 1991). Dissociative cognitive strategies are those that allow distraction from the feelings of distress associated with pain (Spink, 1988).

Association involves either focusing on bodily sensations, completely maintaining awareness of the physical factors that relate to performance, or changing the appraisal of the pain (e.g., concentrating on the burning or warming sensations, separating the painful body part from the rest of their body by framing it) (Weinberg, Smith, Jackson, & Gould, 1984). Predominantly, associative cognitive strategies allow individuals to constantly monitor their internal states (Spink, 1988). Other conceptions use relaxation techniques designed to reduce the anxiety and fear that is associated with pain and thereby lessen the pain and increase tolerance.

Another cognitive conception that attempts to integrate these various strategies is self-efficacy manipulation (Bandura, 1977, 1986). Reactions to pain are dependent on individuals' perception of their ability to cope with the pain. Pain coping behavior can be mediated by efficacy expectations. Self-expectancies are, in turn, a function of past successes and failures at coping with pain, which are attributed to personal abilities (Dolce, Doleys, Raczynski, Lossie, Poole, & Smith, 1986). Thus, attention deployment, cognitive appraisal, and fear arousal can influence pain, but the ability to cope with the pain can be enhanced by elevating people's sense of coping self-efficacy (e.g., Weinberg, Gould, Yukelson, & Jackson, 1981; Weinberg, Jackson, & Gould, 1979). This promotes their resourcefulness and persistence in applying those pain tolerance strategies discussed earlier, enhances their mobilization of cognitive resources to divert attention away from the pain, and reduces distressing anticipations that can produce anxiety and thereby exacerbate pain (Williams & Kinney, 1991).

Fear and the anticipation of pain often lead individuals to refrain from coping and to experience coping attempts as aversive (Williams & Kinney, 1991). Often, expected painful outcomes are primary in determining pain coping behavior. In a treatment setting, people are more likely to do what they expect to be rewarding rather than what they expect to be aversive or harmful. Thus, when outcomes depend upon effective coping resources, expected outcomes will depend upon judgments about how well one can execute and sustain the requisite responses. Self-judged ineffectiveness will lead people to expect aversive outcomes, whereas self-judged effectiveness will lead them to expect more positive outcomes. The confidence that one can successfully accomplish a task, the belief that one has the means to do it, and the optimism that success will eventually ensue leads people to attempt tasks that they otherwise might avoid (Taylor, 1989). Therefore, higher levels of self-efficacy for managing and tolerating pain should lead to greater tolerance, independent of pain per se and of anticipated painful outcomes (Williams and Kinney, 1991).

Related to self-efficacy theory is Rotter's (1966) proposal that there are individual differences in perceived sources of behavioral reinforcements; that is, a person's locus of control. Dishman and Gettman (1980) investigated how a person's locus of control is pertinent to health-relevant or health-related behavior. Their findings can perhaps be extended to the rehabilitation of athletes in a clinical setting. Some individuals expect their rehabilitation to be influenced by personal actions (internal locus of control) or by either the actions of others or by chance occurrence (external locus of control). The time taken to successfully complete sport injury rehabilitation can be greatly influenced by dedication to the program independent of scheduled sessions with the clinician. For those patients who have predominantly an external locus of control, it is possible that their rehabilitation may be lengthened due to their inability to adhere to the program outside of scheduled sessions because they are dependent on the actions of the clinician. The opposite may be surmised for those who have predominantly an internal locus of control; their rehabilitation may be quickened due to their adherence to the program outside of scheduled sessions because they are dependent on personal actions, rather than the actions of the clinician. Therefore, what is significant is the importance of beliefs concerning control, not simply whether control is in fact present or absent in these potentially stressful treatment situations (Taylor, 1989).

Using cognitive strategies to increase pain tolerance has been researched in some depth (e.g., Chapman, 1980; Friedman et al., 1985; Gauron & Bowers, 1986; Melzack, 1973; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). Results vary depending upon each person's ability to utilize the strategy employed. Because attentional capacity is somewhat limited, one factor to bear in mind is that it is reasonable to suppose that when more attention is directed to a distraction task, less attention is available for thinking about pain. Therefore, the more effective the distraction task is, the more likely it will lower pain and increase tolerance (McCall & Malott, 1984). Williams and Kinney (1991) found that a distraction task, which required subjects to overtly perform in response to continual challenges posed by ever-changing stimulus configurations (a small pocket electronic game called "Popeye" manufactured by Nintendo, Inc.), was much more attentionally demanding and more effective than both verbal-imaginal distraction and relaxation in enhancing tolerance of acute pain (hand immersion in a cold-pressor bath with a constant and uniform water temperature of 0.1 ^{0}C).

Friedman et al. (1985) found that giving subjects the chance to ascribe the uncomfortable sensations to a normal and safe physiological process (rather than taking the sensation as a sign of possible damage) increased tolerance.

In this study, subjects were shown a brief typewritten paragraph (supposedly from a college text) in which the physiological responses of the hand to cold-water immersion are described in terms of cutaneous changes and vasoconstriction. Results showed a greater tolerance to pain in this experimental group. This is a significant finding when extrapolated to sport injury rehabilitation in that, when patients are fully informed of the procedure and time involved to recovery, their pain tolerance could increase. Duda et al. (1989) and Fisher et al. (1988) also found that the more knowledge athletes were given about the rehabilitation regimen, especially as it relates to the likelihood of pain and effort needed, the more likely athletes are to adhere to the regimen and the greater their tolerance to pain. This is consistent with the findings of Egbert, Battit, Welch, and Bartlett (1964) who showed that fully informing surgical patients of the expected postoperative sensations greatly increased pain tolerance and decreased the need for analgesics.

Numerous studies have examined the effect of different instructional manipulations on pain tolerance (Kanfer & Goldfoot, 1966; Kanfer & Seidner, 1973; Stevenson, Kanfer, & Higgins, 1984; Thorn & Williams, 1989). By providing subjects with controlling responses that they can utilize at their own discretion, tolerance of aversive stimuli can be affected. Stevenson et al. (1984) reported that providing subjects with goals significantly enhanced their ability to tolerate the cold pressor stimulus. Similarly, Thorn and Williams (1989) tested the effects of instructing subjects to tolerate ischemic pain for a fixed amount of time (15 min) versus an unspecified amount of time ("last as long as you can"). The results suggest that goal specification (i.e., specific time goals) for tolerating the pain is associated with lower absolute pain ratings and higher tolerance times. Thorn and Williams suggested that providing patients/subjects with an instructional set in and of itself can be therapeutic in helping subjects cope with pain.

Research has shown that runners employ psychological strategies during long distance runs (Morgan, 1978; Morgan & Pollock, 1977). One strategy, termed association, directs runners' focus to their bodily sensations, completely maintaining awareness of their physical factors that relate to performance. Specifically, "runners constantly monitor bodily signals of respiration, temperature, heaviness in the calves and thighs, abdominal sensations and the like . . . they keep reminding themselves to stay loose to relax and not tie up" (Morgan, 1978, p. 39). Runners state that, by employing this strategy, they are able to keep in touch with their bodily cues and use these cues to modify their pace and stride depending on the physiological feedback they receive. The second strategy, termed dissociation, is virtually the opposite in that runners think about anything else but their own bodily feelings. According to Morgan, "the runner who dissociated purposely cuts himself off from the sensory feedback he receives from his body" (p. 39). The dissociative strategy is used as a method of blocking out the pain, discomfort, and boredom that often accompanies long distance running. Similar coping strategies have been used in pain tolerance experiments and exercise/rehabilitation adherence studies (Pennebaker & Lightner, 1980; Pennebaker & Skelton, 1978; Sachs & Sachs, 1981).

Pennebaker and Lightner (1980) and Pennebaker and Skelton (1978) found that the dissociative strategy was more effective in increasing pain threshold than the associative strategy because increased attention to internal cues produces greater perception of fatigue and therefore decreases performance. Similarly, Weinberg et al. (1984) found that the dissociation strategy produced the most persistence in an endurance leg lift. The leg lift had aversive consequences (i.e., pain) and required maximum effort. Subjects employing the dissociative strategy during the leg lift were evidently able to distract their attention away from the pain of the muscle soreness and fatigue in their leg and were able to hold their leg out significantly longer than those instructed to associate. The group that utilized the dissociation strategy were able to tolerate the pain and thereby increase their effort for longer periods when performing the leg lift. Weinberg et al. also conducted a running experiment but found no significant differences in the strategies employed. They surmised that this was due to the fact that subjects in this experiment were experienced runners and probably already utilized strategies, and these may have conflicted with the strategies they were told to employ for the experiment.

Limitations to Experimentally Induced Pain

Researchers who have investigated experimentally induced pain have used pain stimuli that range from radiant heat, cold pressor, electric shock, mechanical pressure, and ischemic pain. Two of the more popular methods of inducing pain are the cold pressor test and inducing ischemic pain, through application and inflation of a sphygmomanometer cuff and/or use of a grip strength dynamometer. However, as Thorn and Williams (1989) discussed, findings from cold pressor induced pain have limited generalizability to pain problems partly because the cold pressor test does not induce long-lasting pain. The circulating ice water causes the subject's arm to go numb after approximately 5 min (Knuckle, 1949), rendering the pain induction technique ineffective after this time. Friedman et al. (1985) also investigated the effectiveness of the cold water paradigm and found that the change over time of the sensation of the hand to the ice water immersion rendered the technique ungeneralizable to real life pain.

The other popular method of experimentally inducing pain is the ischemic pain technique. In contrast to the cold pressor test, the ischemic pain technique produces a slow-building, long-lasting, aching sensation and, because it lasts longer, may be more similar to the clinical pain state than a short-lived stimulus (Thorn & Williams, 1989).

However, there are certain limitations when inducing pain in an experimental/laboratory setting, despite the technique used. It is worthy to note that, although laboratory pain-induction techniques cannot be directly compared to clinical pain conditions, the results of these studies can lead to ideas worth attention for patients in pain (Thorn & Williams, 1989). Friedman et al. (1985) pointed out that it is important to take into consideration that laboratory studies of pain perception must be scientifically and ethically acceptable and therefore inherently safe. In the laboratory, subjects are aware that the threat of physical harm is minimal because both the experimenter and subject are in control of the noxious stimulation. Subjects know that the noxious stimulation will be terminated at their command or when a safe, predetermined level by the investigator has been reached. This may actually reduce subjects' fear in experimental tests of tolerance of pain (Friedman et al., 1985). If a noxious stimulation must be tolerated in an experiment, subjects tend to utilize the well-learned coping mechanisms that they have found helpful in their past experience (Kanfer & Goldfoot, 1966). This can, therefore, increase their tolerance of pain and give slightly higher values than would normally be present.

Therefore, actual pain as a result of injury is one of the most effective tests of pain tolerance and performance. One major advantage of actual pain over induced pain is that, whereas subjects can terminate the test, they know that the resultant pain they experience will not terminate. In addition, one could surmise that subjects' fear of pain has not been minimized because their pain is a result of actual injury.

One method used to induce actual pain is exercise-induced muscle soreness. It has been established that strenuous, unaccustomed exercise produces damage to muscle and, therefore, soreness (Armstrong, 1984; Clarkson et al., 1992; Smith, 1991). Indirect evidence of damage includes the soreness and stiffness that appear 24-48 hr after the exercise and a prolonged reduction in muscle strength and range of motion (Clarkson et al., 1992). Eccentric actions, where muscles are lengthened as they produce force, have been shown to produce muscle damage. Changes in muscle soreness level after high force eccentric exercise showed that soreness appears 24 hr after exercise and peaks at 48-72 hr postexercise. Soreness slowly dissipates and fully subsides within 8-10 days after exercise (Clarkson et al., 1992). Smith noted that the soreness experienced is only apparent when the muscle is palpated or during movement; at rest there is virtually no pain. Exercise, therefore, may be a stimulus to produce a safe and temporary, yet real to life induced pain.

There are dramatic changes in isometric strength after high force eccentric exercise. Clarkson et al. (1992) found that, immediately after exercise, there is a dramatic loss in strength of over 50%. Strength is gradually, but slowly, restored such that by 10 days after exercise only a slight deficit still remains. Performance of serial concentric or isometric contractions lead to a loss in the ability to produce force. However, unlike eccentric exercise, the strength loss after concentric and isometric exercise is restored in the next several hours. Thus, it would appear that, to induce long-lasting muscle soreness with performance decrements, it is more effective to use eccentric rather than concentric exercise.

There have been many investigations concerning the effectiveness of association and dissociation strategies on pain tolerance and performance using pain stimuli that range from radiant heat, cold pressor, electric shock, mechanical pressure, and ischemic pain. However, use of exercise as a temporary, but effective, pain induction technique has not been utilized to test the effectiveness of association and dissociation strategies.

Summary

It is generally recognized that pain is part of an athlete's experience (Gauron & Bowers, 1986) and that athletes differ in their ability to function and cope with pain following injury. Despite the type of sport or skill level of athlete, pain is consciously perceived at approximately the same physiological level (Anshel, 1990). However, psychological and/or environmental cues can strongly influence pain tolerance levels (e.g., Anshel, 1990; Ryan & Kovacic, 1966; Scott & Gijsbers, 1981; Spink, 1988).

Athletes' attitudes towards pain and the cognitive strategies that they use while experiencing pain may be reflected in their pain tolerance levels and their performance and adherence in sport injury rehabilitation (Meyers et al., 1992). Thus, it is worthwhile for those involved in sport injury rehabilitation to be aware of the effectiveness of cognitive strategies that may assist athletes to overcome the pain to rehabilitation.

There have been a variety of briefly administered cognitive strategies for pain tolerance developed. Two of the more popular cognitive strategies are association and dissociation. These two strategies are useful for clinicians (in particular athletic trainers and physical therapists) and injured athletes because both strategies are brief to administer when acutely painful therapeutic procedures are required during rehabilitation (Anshel, 1990). There is a strong mental component involved in pain and coping with injury. Not only do athletes have to cope with the strong and devastating emotions that are associated with a painful debilitating injury, they also have to cope with their apprehension of the onset of pain as part of their treatment regimen (Fisher et al., 1993). Should athletes concentrate on emotion coping techniques, rather than problem-focused coping techniques, their healing may be delayed and their pain exacerbated (Smith et al., 1990).

Pain induction techniques have been used to determine the effectiveness of cognitive strategies, such as association and dissociation, on pain tolerance and performance. However, one limitation of these techniques is that they are inherently safe and subjects know the test can be terminated at any time. Not only will the test be terminated but the pain experienced will also be terminated because the pain is due to the noxious stimulation present. Thus, it is possible that tolerance and performance levels are higher in experimental settings than would normally be present in real life situations.

Exercise-induced muscle soreness is one pain induction technique that attempts to alleviate these limitations and therefore provide more realistic levels of pain tolerance and performance. The pain, stiffness, prolonged reduction in muscle strength, and decreased range of motion that appear 24-48 hr after strenuous eccentric exercise does not fully subside until 8-10 days after the initial bout of exercise (Clarkson et al., 1992). Using exercise induced muscle soreness as noxious stimulation to test the effectiveness of two cognitive strategies of association and dissociation has not been investigated. Subjects experience long lasting, real life pain and their pain tolerance and performance levels would not be limited by the knowledge that terminating the test would terminate their pain. Therefore, the cognitive strategies of association and dissociation can be tested on athletes experiencing induced delayed onset muscle soreness to investigate their effect on pain tolerance and performance.

Chapter 3

METHODS AND PROCEDURES

The methods incorporated within this study are presented in the following chapter. The sections that follow are listed under the following headings: (a) selection of subjects, (b) testing instruments, (c) testing procedures, (d) treatment of data, and (e) summary.

Selection of Subjects

Data collection for this study was conducted from October, 1992 to November, 1992. All subjects were college athletes recruited from Ithaca College, Ithaca, NY. Twenty females and 14 males, ranging in age from 18-22 years, volunteered to participate in this study.

Prior to beginning the study, each subject filled out a MHQ, read, and signed the ICF that described the experimental procedures. If subjects had no history of knee and/or back problems, used no medication, and had not strength trained the lower body for a minimum of 2 months prior to testing, they were accepted for participation in the study.

Testing Instruments

Strength performance data were measured on the Biodex System 2, an isokinetic muscle function dynamometer.

Strength measurements were taken of eccentric knee flexion and extension for the specific variables of peak torque (PT), total work (TW), and average power (AP).

The SAT was a shortened version of the state portion of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) (see Appendix C). The MSS was a measure designed by the investigator to measure the perceived level of muscle soreness (see Appendix E). The Pre-PPS was a measure designed by the investigator to measure perception of performance prior to testing (see Appendix D). The Post-PPS was a measure designed by the investigator to measure perception of performance after testing (see Appendix F).

Testing Procedures

All subjects completed three sessions of data collection. Although each session contained some identical procedures (e.g., performing a series of eccentric maximal resistive exercises to ascertain performance of the quadricep and hamstring muscle groups and completing the SAT), Session 3 contained unique procedures for subjects (e.g., listening to a prepared tape prior to the Biodex System 2 testing). These unique procedures were dependent on particular group assignments. Data collection sessions are subsequently described in greater detail. Explanations and directions were given prior to each test in addition to a warm-up/practice period.

The repeated testing sessions were conducted in the same laboratory under the same conditions. Each subject was tested by the same female investigator, and no other person was permitted to be present in the room. Identical instructions were given, and no performance feedback (either verbal or visual) was provided.

Thirty subjects completed all three testing sessions but there were 4 subjects who only completed the first testing session. These 4 subjects were eliminated from the study after the first session of testing because they reported no pain in both muscle groups when they appeared for Session 2. It had been decided prior to beginning data collection that subjects who did not report muscle soreness in Session 2 could not be used in the final data analysis. The experimental protocol necessitated that subjects experience muscle soreness.

Testing Session 1

Upon entering the laboratory, each subject completed the SAT. The subject was then seated on the Biodex System 2 with belts securely fastened across the chest, lap, over the dominant leg, and around the lower shin. The proper height and position of the chair were found by aligning the lateral condyle of the femur with the center of the attachment shaft, as recommended by the manufacturer (Biodex Corporation, 1988). Once the subject was in the correct position, biographical information (e.g., name, subject number, sex, birth date, age, height, and weight) was entered into the Biodex System 2 computer and saved. Before the actual testing began, an explanation of the test was given followed by a warm-up period of two sets of 10 submaximal eccentric contractions. This allowed subjects to become familiar with the movement speed of the attachment shaft (90 ^{0}/sec) and with the resistive action they had to provide. Baseline strength measurements were then determined by the performance of maximal resistive eccentric exercise tests on the Biodex System 2. To perform eccentric contractions of the quadricep and hamstring muscle groups, subjects contracted their muscles in opposition to the robotic motion of the attachment shaft of the Biodex System 2.

To ascertain eccentric strength performance of the quadricep and hamstring muscle groups, the "passive" mode was selected and a speed of 90 ^{0}/sec was set for the following protocol: two sets of 10 repetitions of maximal eccentric contractions, two sets of 40 repetitions of maximal eccentric contractions, and five sets of 10 repetitions of maximal eccentric contractions. Each set was separated by a 180-s rest period. To ensure muscle soreness was induced, subjects were then required to perform leg squats at 80% of their maximal lift to involuntary exhaustion using a Universal gym apparatus. Squats were completed in sets of 10 repetitions with a 2-min rest between sets.

Data were recorded for the specific performance variables of peak torque (PT), average power (AP), and total work (TW). These performance variables were only recorded in the first four sets of exercise--the two sets of 10 repetitions of maximal eccentric contractions and the two sets of 40 repetitions of maximal eccentric contractions. These four sets of exercise were repeated in the following two sessions to compare performance. The five sets of 10 repetitions of maximal eccentric contractions and the series of leg squats to exhaustion in this session were completed to ensure muscle soreness was induced.

Upon completion of testing, subjects were requested to do as little as possible over the next 48 hr to allow the muscle soreness to peak. This included no stretching, jogging, running, bike riding, and/or weight lifting.

Subjects were then assigned to one of three groups. However, to reduce the possibility that by chance the strongest and/or weakest subjects were assigned to the same group, subjects were initially strength matched in groups of three by averaging the peak torques of the hamstring and quadricep muscle groups over the four sets of recorded data. Once a subject was strength matched with two other subjects, each subject within this group of three was then randomly assigned to either the association, dissociation, or control group. Subjects were not informed to which group they were assigned until they were debriefed at the end of Session 3.

Testing Session 2

Upon arrival, subjects completed the SAT, MSS, and Pre-PPS. The Pre-PPS assessed how subjects thought they would perform compared to their Session 1 testing. Each subject was also asked which muscle group provided more pain: the hamstring or the quadricep muscle group. Of major concern to the investigator was the possibility that subjects might experience major muscle tear(s) during the second and third sessions of testing. In order to minimize this possibility, and after consultation with the athletic training staff, each subject was given the following identical instruction prior to testing on the Biodex System 2:

> You have delayed onset muscle soreness of the quadricep and hamstring muscle groups. This

soreness can be indicative of a degree of muscle damage. In this testing session, I want you to give a maximal effort on every repetition. However, should you experience any sharp or intense pain, I want you to stop immediately.

Subjects then completed the Biodex System 2 measurements in a fashion identical to Session 1. The warm up/practice session began with two-four repetitions of simply allowing the Biodex System 2 to move the leg, and subjects were then encouraged to gradually impose a resistive effort. The warm up/practice period comprised of two sets of 10 submaximal eccentric contractions, separated by a 1-min rest. Subjects then completed the testing protocol of two sets of 10 repetitions of maximal eccentric contractions and two sets of 40 repetitions of maximal eccentric contractions, each set separated by a 180-s rest.

Upon completion of the Biodex System 2 testing, subjects completed the Post-PPS. The Post-PPS (like the Pre-PPS) was a manipulation check to assess subjects' strength performance after they had been tested. Subjects were then asked to return 3 hr later, and again requested to minimize their physical activity.

Testing Session 3

Upon entering the laboratory, subjects again completed the SAT, MSS, and Pre-PPS. Prior to testing on the Biodex System 2, subjects listened to a prepared tape twice. The tape contained either an association or dissociation strategy or a control instruction. Subjects also read the identical dialogue while listening to the tape. The dialogues for the tapes are provided in Appendix I. The two times that subjects listened to their tape was separated by a warm-up/practice set of 10 repetitions as described in Session 2. After listening to the tape a second time, subjects completed another warm-up/practice set of 10 repetitions.

Identical verbal instructions were given in Session 3 as in Session 2, and then subjects were retested. The same protocol of two sets of 10 repetitions of maximal eccentric contractions and two sets of 40 repetitions of maximal eccentric contractions, each set separated by a 180-s rest, was followed. However, the tape was listened to again after the two sets of 10 repetitions had been completed in preparation for the two longer sets of 40 repetitions.

Upon completion of the Biodex System 2 testing, subjects completed the Post-PPS and SEQ. Subjects were then debriefed and given the opportunity to view their results and listen to the other tapes.

Treatment of Data

Intraclass correlation coefficients (_R_) were calculated for the two sets of 10 repetitions and two sets of 40 repetitions to determine the most reliable data for use as the dependent variables in further analyses of data. Mixed model 3 (Group) x 3 (Session) analyses of variance (ANOVAs) assessed the effects of the cognitive treatments, time, and their interactions on the performance variables (PT, TW, and AP) of the hamstring and quadricep muscle groups for 10 and 40 repetitions. Significant differences were located by univariate ANOVAs and Tukey post hoc tests. Descriptive statistics were provided for the SAT and Pre-PPS in Sessions 2 and 3. MSS, Pre-PPS, and Post-PPS responses, as measured in Session 2, were condensed into categories of high and low. Mixed model 2 (MSS) x 2 (Pre-PPS) x 2 (Post-PPS) x 3 (Session) ANOVAs, and 2 (MSS) x 2 (Post-PPS) x 3 (Session) ANOVAs assessed the effects of the cognitive treatments, time, and their interaction on the performance variables (PT, TW, and AP) of the hamstring and quadricep muscle groups for 10 and 40 repetitions. Significant differences were located by univariate ANOVAs and Tukey post hoc tests. Univariate

ANOVAs and post hoc Tukey analyses determined the treatment effect on the MSS, Pre-PPS, and Post-PPS in Session 3. Descriptive statistics were provided for groups and individual subjects for the SEQ.

Summary

Female ($\underline{n}$ = 20) and male ($\underline{n}$ = 14) athletes volunteered to participate in this investigation. Strength measurements were obtained in Session 1, and muscle soreness was induced in the hamstring and quadricep muscle groups. Four subjects were excused from the investigation after reporting no pain in both muscle groups at the beginning of Session 2. The remaining 30 subjects were tested two more times to determine strength loss due to the soreness, and questionnaires were completed in each testing session. The third testing session was completed with some subjects utilizing either an association or dissociation strategy designed to increase pain tolerance and performance. The effectiveness of these strategies were tested. Intraclass correlation coefficients were calculated to determine the most reliable value for PT, TW, and AP data. Mixed model ANOVAs, univariate ANOVAs, and post hoc Tukey analyses assessed the effects of time on PT, TW, and AP; the effects of treatment on the MSS, Pre-PPS, and Post-PPS in Session 2 and on PT, TW, and AP over the three testing sessions; and the effects of treatment on the MSS, Pre-PPS, and Post-PPS in Session 3. Descriptive data were provided for the SAT and Pre-PPS scores in Sessions 2 and 3, and for the responses to the SEQ.

Chapter 4

ANALYSIS OF DATA

The overall purposes of this investigation were to ascertain whether athletes, once hamstring and quadricep muscle soreness/damage had been exercise induced, were able: (a) to increase their muscular strength performance scores, as measured by PT, TW, and AP, in Session 3 from Session 2 by utilizing a cognitive strategy, and (b) to determine whether individual perception of performance (as measured by the Post-PPS in Session 3), and therefore pain tolerance, would be increased by utilizing a cognitive strategy.

The chapter is divided into the following sections: (a) description of subjects, (b) internal consistency of performance data, (c) analyses of the performance variables, PT, TW, and AP, (d) analyses of SAT and Pre-PPS (Sessions 2 and 3), (e) analyses of the MSS, Pre-PPS, and Post-PPS in Session 2 and PT, TW, and AP over the three testing sessions, (f) analyses of the MSS, Pre-PPS, and Post-PPS in Session 3, (g) analysis of SEQ item responses, and (h) summary.

Description of Subjects

Twenty females and 14 males, ranging in age from 18-22 years, volunteered to participate in this investigation. Four subjects reported no pain in both muscle groups when they reported for Session 2 and, therefore, were eliminated from the investigation. The remaining subjects were asked to continue in the investigation as a result of their rating of muscle soreness in the second testing session. Hence the analysis of data was performed on a total sample size of 30 (18 females, and 12 males). They had healthy knees, used no medications, were moderately to highly active athletes, and had not engaged in regular strength training of the lower extremity for at least 2 months prior to testing.

Internal Consistency of Performance Data

The intraclass correlation coefficients ($\underline{R}$) for the two sets of 10 repetitions and two sets of 40 repetitions for the performance variables of PT, TW, and AP of the hamstring and quadricep muscle groups over the three testing sessions are presented in Table 1. Most studies that have investigated reliability of performance measures on isokinetic muscle function dynamometers (i.e., the Biodex System 2 and Cybex II) have calculated test-retest reliability values of .95 and higher (e.g., Barbee & Landis, 1984; Feiring, Ellenbecker, & Derscheid, 1990; McCleary & Andersen, 1992; Perrin, 1986). That suggests that test-retest reliabilities for PT, TW, and AP for knee flexion and extension on the Biodex System 2 should be .95 or higher.

Table 1

Intraclass Correlation Coefficients for Peak Torque (PT), Total Work (TW), and Average Power (AP)

	PT	TW	AP	
	R	*R*	*R*	R_M[a]
2 sets of 10 repetitions				
Hamstrings				
Session				
1	.96	.97	.97	
2	.98	.99	.99	
3	.98	.98	.98	
				.97
Quadriceps				
Session				
1	.92	.97	.95	
2	.93	.99	.98	
3	.93	.98	.98	

(table continues)

	PT	TW	AP	
	R	R	R	R_M[a]
2 sets of 40 repetitions				
Hamstrings				
Session				
1	.93	.88	.82	
2	.97	.97	.98	
3	.92	.97	.98	
				.93
Quadriceps				
Session				
1	.91	.93	.93	
2	.93	.97	.98	
3	.97	.98	.98	

[a]R_M is the mean of R values of all performance variables of both muscle groups for 10 and 40 repetitions over the three testing sessions.

However, in this investigation internal consistency between sets was calculated. It is expected that this value should be higher than that calculated for test-retest reliability (i.e., stability). Should the internal consistency value be lower than that reported in the literature for test-retest reliability (minimum of .95), it is reasonable to suppose that had test-retest reliability been measured it would have been lower than these purported values.

The $\underline{R}$ values of the hamstring and quadricep muscle groups for the two sets of 10 repetitions over the three testing sessions ranged from .92 to .99, with a mean $\underline{R}$ = .97. Because the scores from the two sets were consistent, the analyses of performance data were conducted using all scores of the two sets for 10 repetitions.

The $\underline{R}$ values of the hamstring and quadricep muscle groups for the two sets of 40 repetitions over the three testing sessions ranged from .82 to .99, with a mean $\underline{R}$ = .93. In comparison to the scores for the 10 repetitions, the range of scores was greater, and there were more values less than .95. Thus, it was decided to use only the scores from the first set of 40 repetitions for the analyses of performance data, with the speculation that fatigue could be a contributing factor to reduced scores during the second set of 40 repetitions.

Analyses of the Performance Variables, PT, TW, and AP

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group PT for 10 repetitions showed a significant Group x Session interaction ($F = 2.82$, $p < .05$). The means, standard deviations, and F values are presented in Table 2. Follow-up ANOVAs were not able to solve the interaction effect (see Figure 1).

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group TW for 10 repetitions showed a significant session effect ($F = 87.22$, $p < .05$). The means, standard deviations, and F values are presented in Table 2. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 2).

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group AP for 10 repetitions showed a significant Group x Session interaction ($F = 2.78$, $p < .05$). The means, standard deviations, and F values are presented in Table 2. Follow-up ANOVAs were not able to solve the interaction effect (see Figure 3).

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group PT for 10 repetitions showed a

Table 2

Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Hamstrings at 10 Repetitions

	M	SD	F
PT (Nm)			
Group Effect			
Association	79.24	22.57	
Dissociation	69.48	24.48	1.24
Control	66.66	25.56	
Time Effect			
Session 1	95.51	25.08	
Session 2	56.38	25.42	81.51*
Session 3	58.99	24.84	
Interaction			2.82*
TW (J)			
Group Effect			
Association	685.02	275.35	
Dissociation	585.06	234.25	1.15
Control	542.42	225.42	

(table continues)

	M	SD	F
Time Effect			
Session 1	940.26	294.99	
Session 2	440.14	256.08	87.22*
Session 3	432.09	230.88	
Interaction			2.48
AP (W)			
Group Effect			
Association	34.81	13.62	
Dissociation	29.30	12.36	1.26
Control	27.59	11.49	
Time Effect			
Session 1	46.44	14.30	
Session 2	22.72	12.76	86.30*
Session 3	22.54	11.69	
Interaction			2.78*

Note. Peak torque is measured in newton-meters (Nm); total work is measured in joules (J); and average power is measured in watts (W).

* $p < .05$.

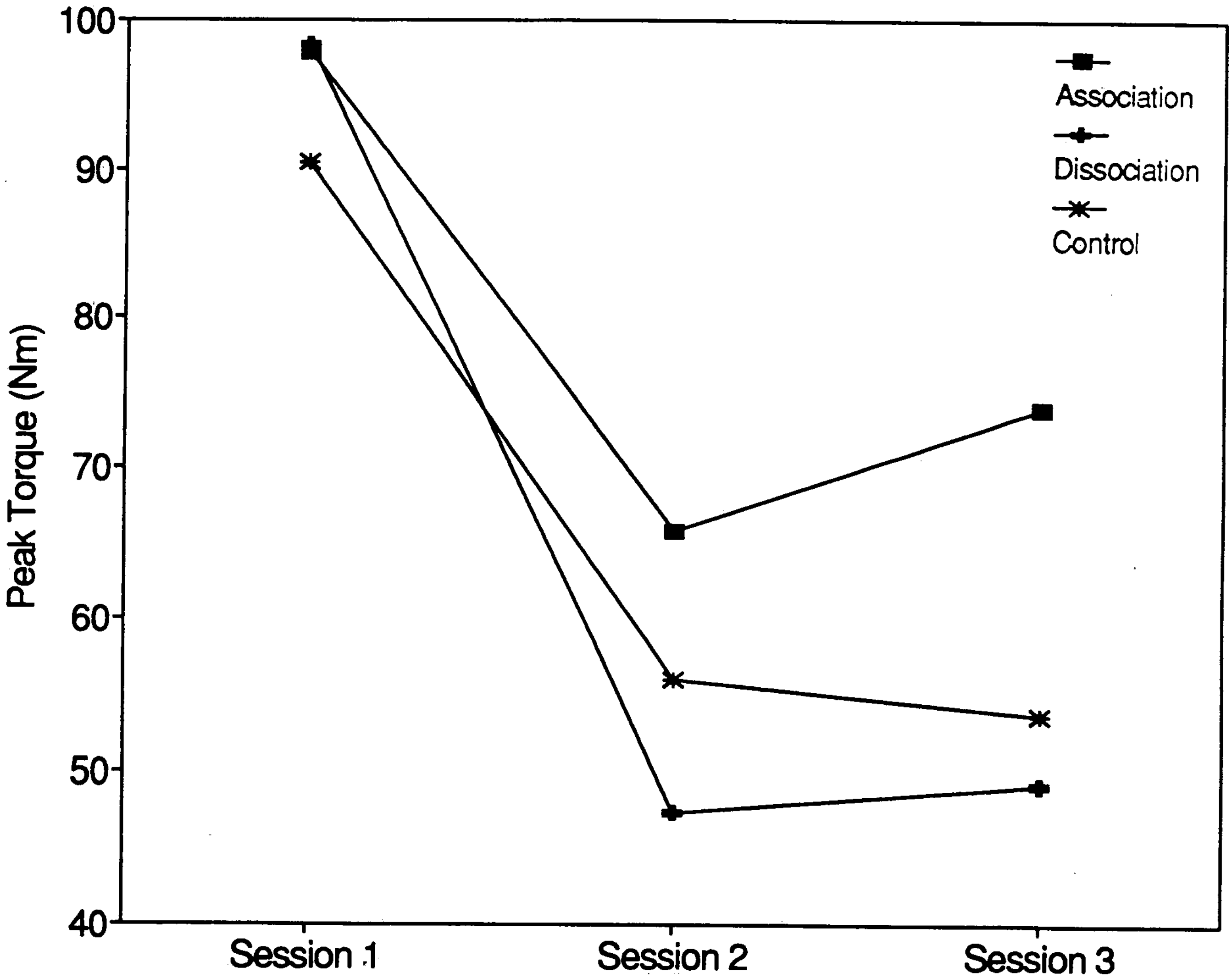

Figure 1. Means for peak torque of the hamstrings at 10 repetitions.

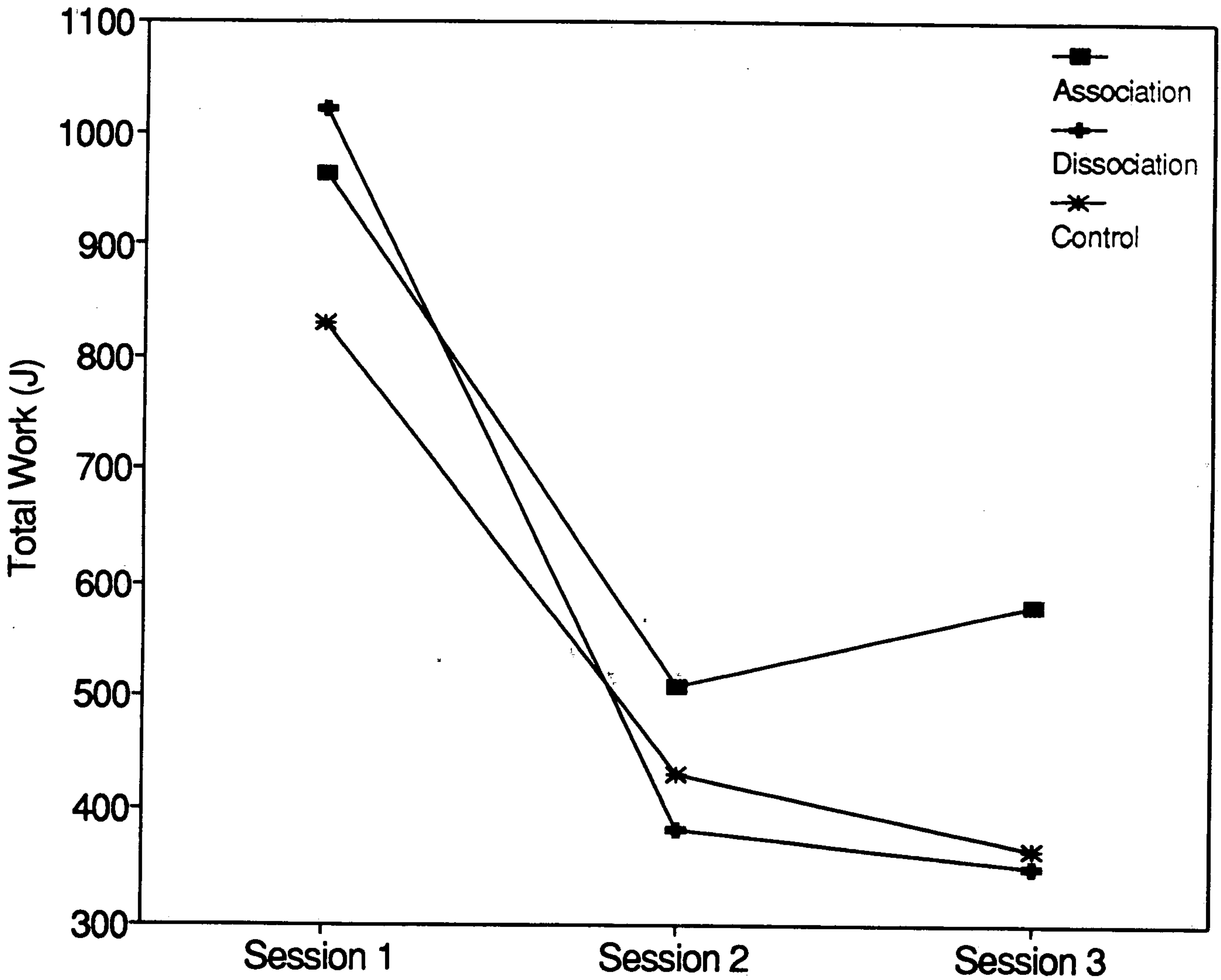

Figure 2. Means for total work of the hamstrings at 10 repetitions.

significant Group x Session interaction ($\underline{F} = 2.83$, $\underline{p} < .05$). The means, standard deviations, and $\underline{F}$ values are presented in Table 3. Follow-up ANOVAs were not able to solve the interaction effects (see Figure 4).

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group TW for 10 repetitions showed a significant session effect ($\underline{F} = 55.45$, $\underline{p} < .05$). The means, standard deviations, and $\underline{F}$ values are presented in Table 3. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 5).

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group AP for 10 repetitions showed a significant session effect ($\underline{F} = 48.17$, $\underline{p} < .05$). The means, standard deviations, and $\underline{F}$ values are presented in Table 3. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 6).

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group PT for 40 repetitions showed a significant session effect ($\underline{F} = 66.77$, $\underline{p} < .05$). The means, standard deviations, and $\underline{F}$ values are presented in Table 4. Post hoc Tukey analyses revealed that there were significant

Table 3

Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Quadriceps at 10 Repetitions

	M	SD	F
PT (Nm)			
Group Effect			
Association	191.65	46.38	
Dissociation	171.53	45.02	0.63
Control	173.62	54.00	
Time Effect			
Session 1	214.05	50.88	
Session 2	152.64	43.39	41.97*
Session 3	170.11	52.80	
Interaction			2.83*
TW (J)			
Group Effect			
Association	1212.25	423.70	
Dissociation	1028.08	312.67	1.02
Control	1035.97	276.87	

(table continues)

	M	SD	F
Time Effect			
Session 1	1580.11	407.60	
Session 2	1061.43	359.28	55.45*
Session 3	1049.40	391.00	
Interaction			1.86
AP (W)			
Group Effect			
Association	73.01	22.50	
Dissociation	61.21	17.62	1.00
Control	61.30	16.58	
Time Effect			
Session 1	80.27	20.24	
Session 2	56.37	17.83	48.17*
Session 3	56.55	20.19	
Interaction			2.00

Note. Peak torque is measured in newton-meters (Nm); total work is measured in joules (J); and average power is measured in watts (W).

* $p < .05$.

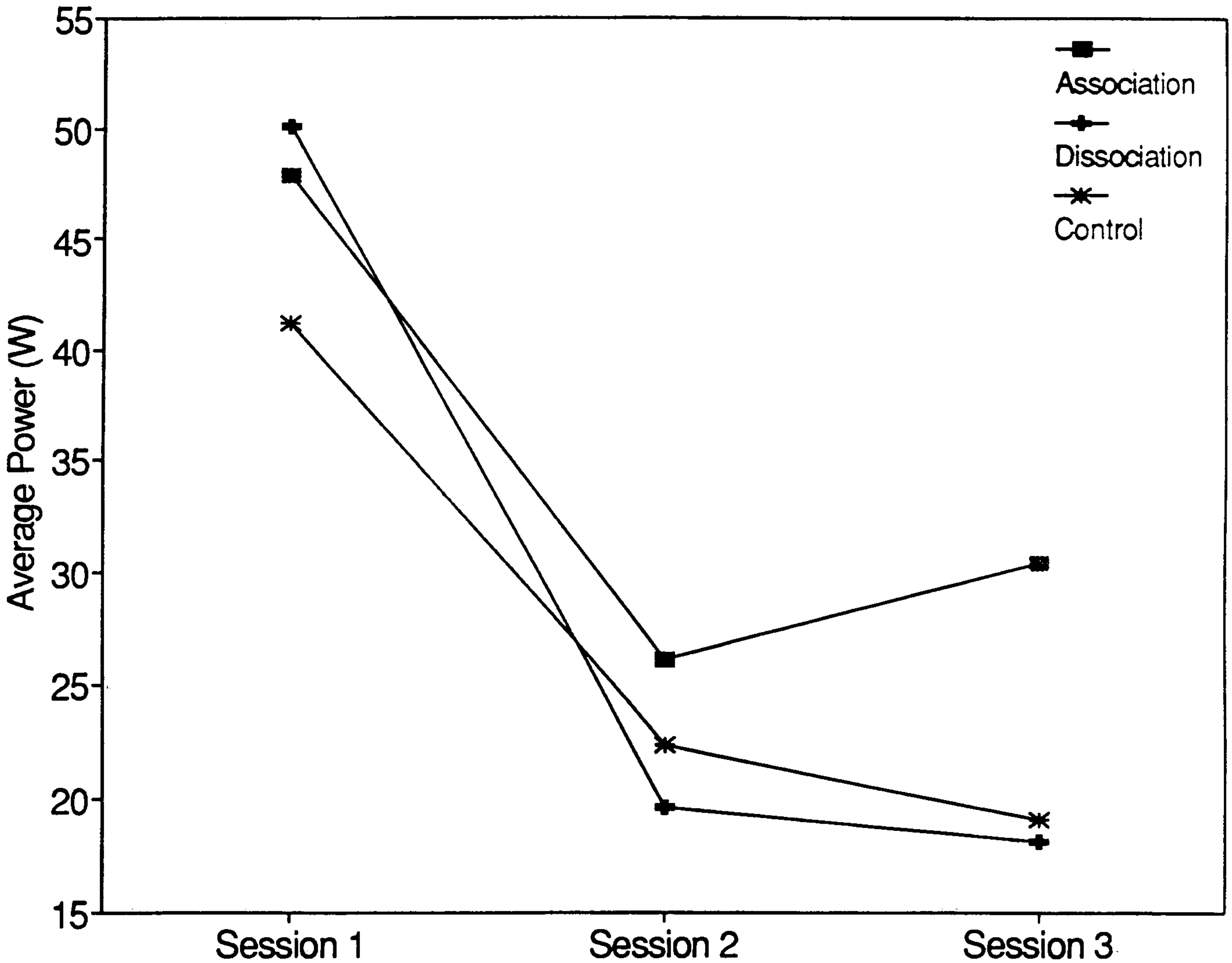

Figure 3. Means for average power of the hamstrings at 10 repetitions.

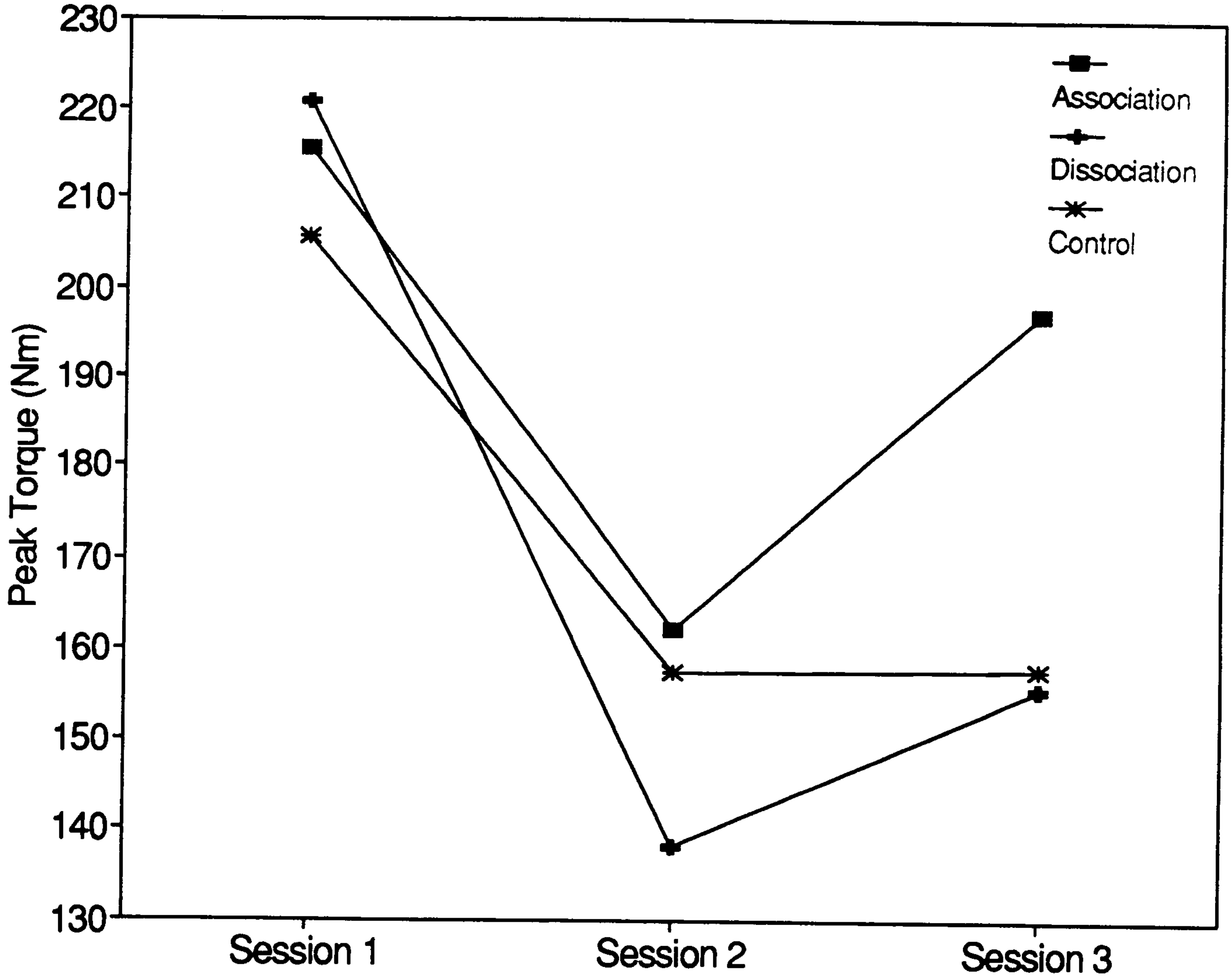

Figure 4. Means for peak torque of the quadriceps at 10 repetitions.

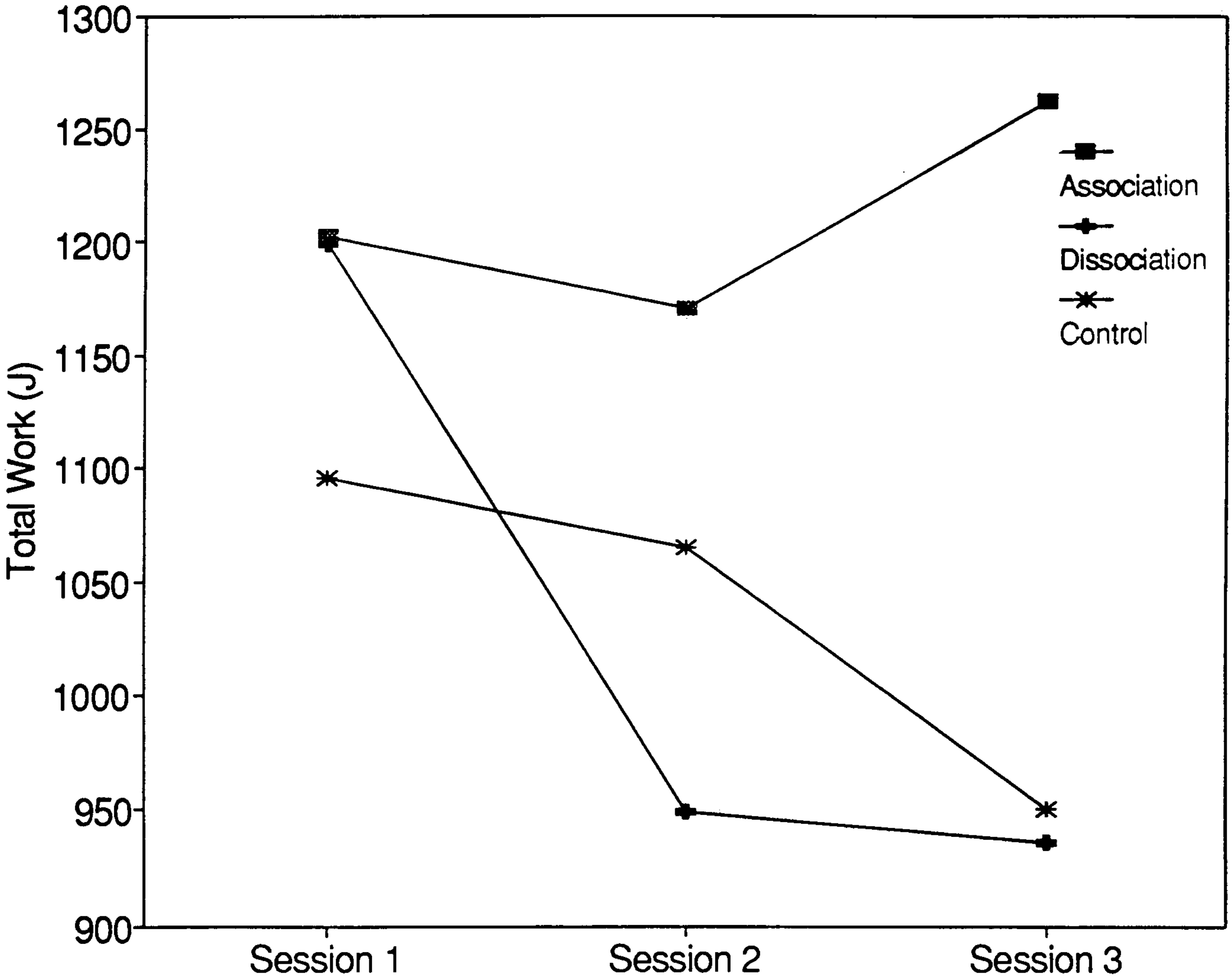

Figure 5. Means for total work of the quadriceps at 10 repetitions.

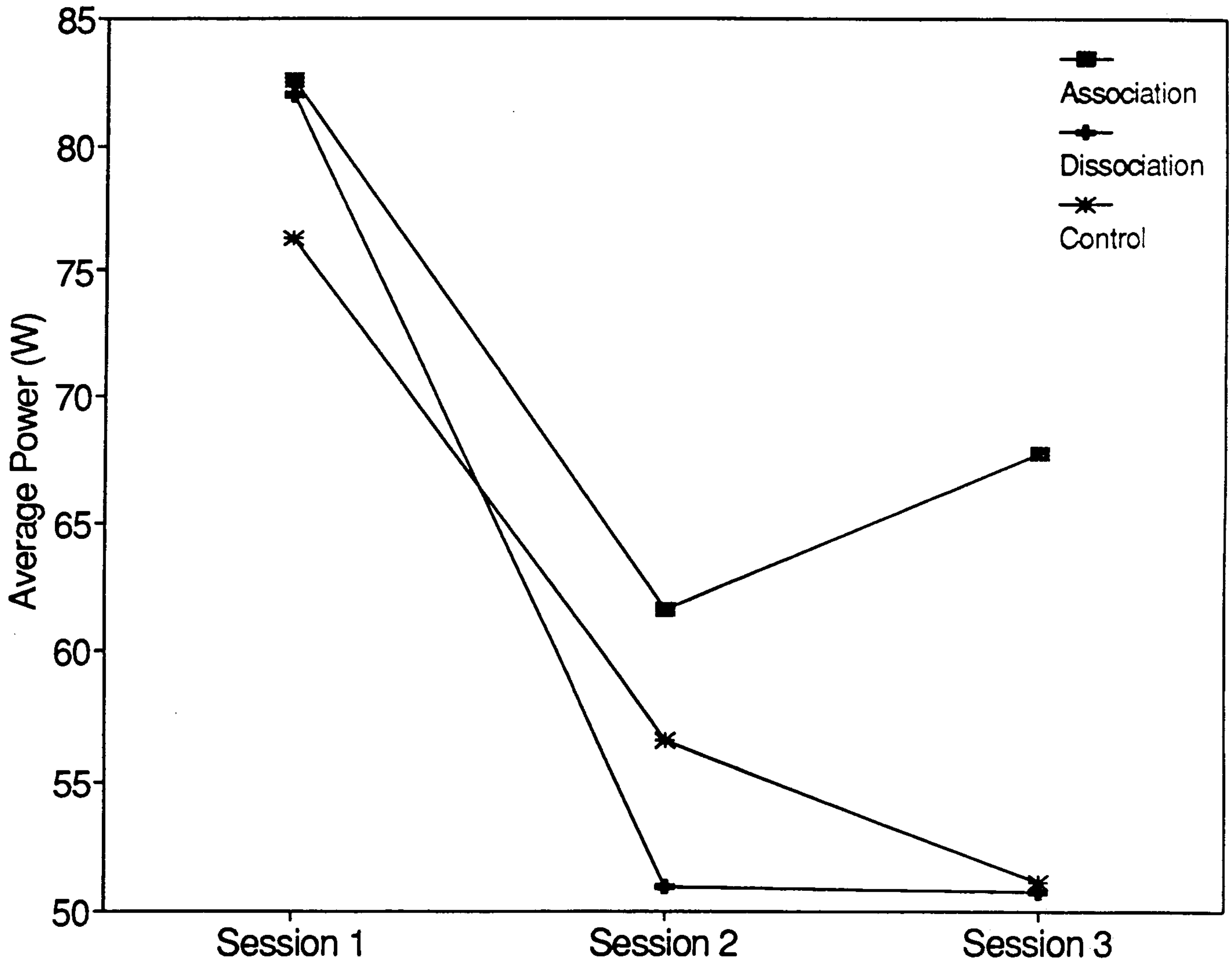

Figure 6. Means for average power of the quadriceps at 10 repetitions.

differences between Session 1 and Sessions 2 and 3 (see Figure 7).

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group TW for 40 repetitions showed a significant session effect (F = 55.45, p < .05). The means, standard deviations, and F values are presented in Table 4. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 8).

A 3 (Group) x 3 (Session) mixed model ANOVA on the hamstring muscle group AP for 40 repetitions showed a significant session effect (F = 50.15, p < .05). The means, standard deviations, and F values are presented in Table 4. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 9).

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group PT for 40 repetitions showed a significant session effect (F = 27.97, p < .05). The means, standard deviations, and F values are presented in Table 5. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 10).

Table 4

Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Hamstrings at 40 Repetitions

	M	SD	F
PT (Nm)			
Group Effect			
Association	191.65	46.38	
Dissociation	171.53	45.02	0.23
Control	173.62	54.00	
Time Effect			
Session 1	92.06	22.87	
Session 2	61.88	26.80	66.77*
Session 3	58.99	24.84	
Interaction			1.56
TW (J)			
Group Effect			
Association	2500.34	936.62	
Dissociation	2072.61	888.17	1.37
Control	1992.14	836.72	

(table continues)

	M	SD	F
Time Effect			
Session 1	2354.68	708.90	
Session 2	1286.58	741.22	74.04*
Session 3	1273.96	640.11	
Interaction			1.73
AP (W)			
Group Effect			
Association	32.30	11.10	
Dissociation	24.66	10.77	1.82
Control	25.36	10.76	
Time Effect			
Session 1	36.78	10.54	
Session 2	22.32	12.13	48.10*
Session 3	23.22	10.87	
Interaction			0.66

Note. Peak torque is measured in newton-meters (Nm); total work is measured in joules (J); and average power is measured in watts (W).

* $p < .05$.

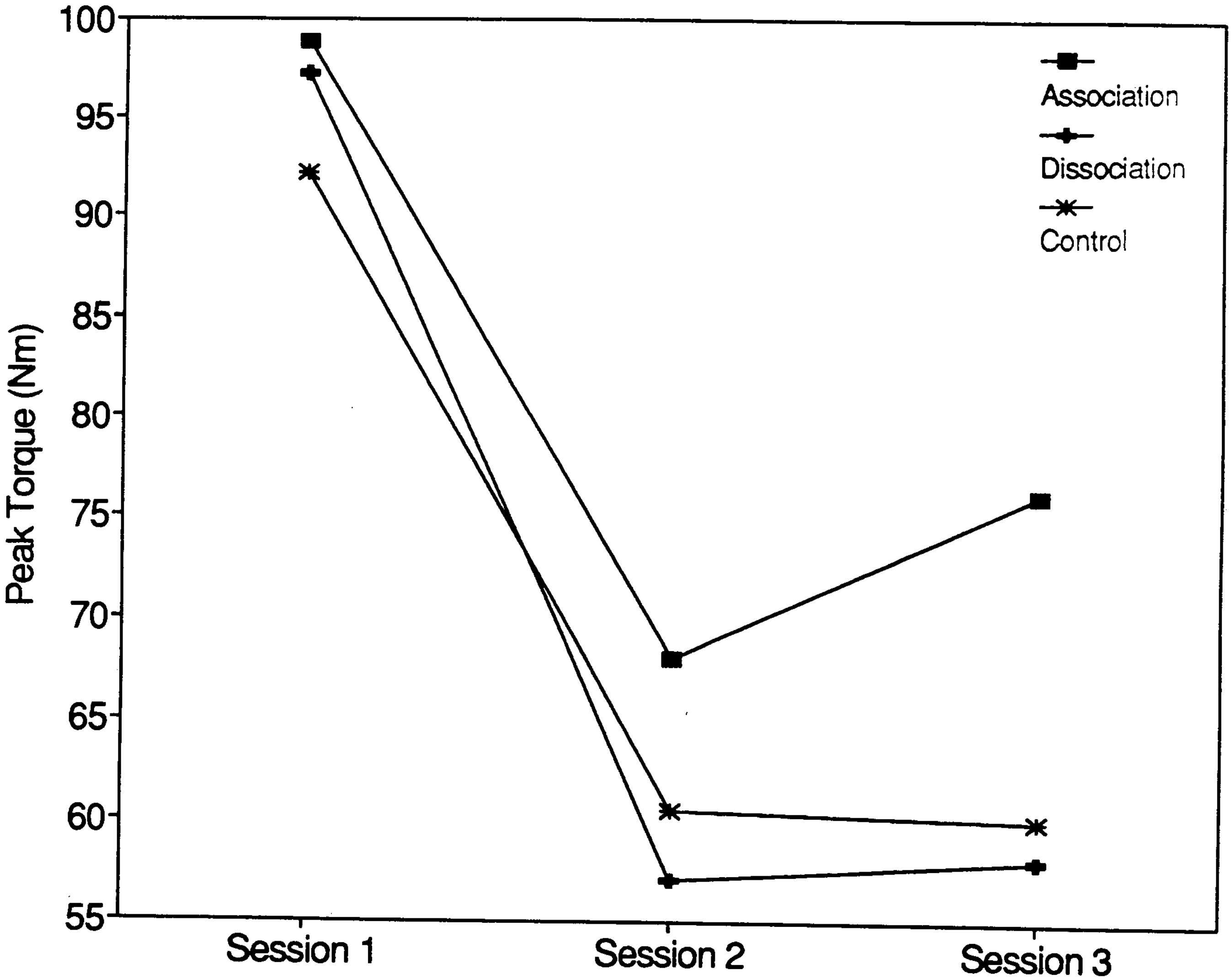

Figure 7. Means for peak torque of the hamstrings at 40 repetitions.

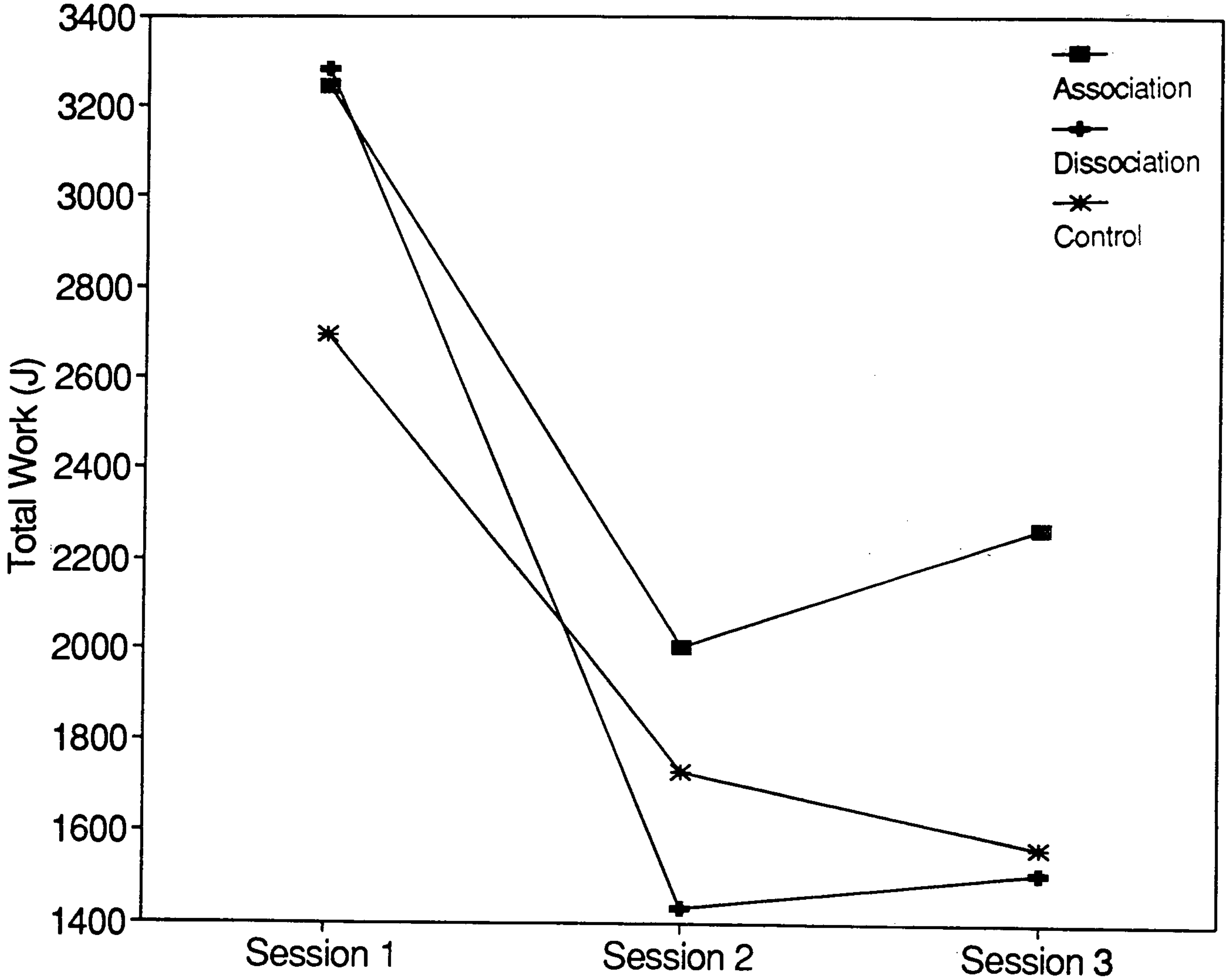

Figure 8. Means for total work of the hamstrings at 40 repetitions.

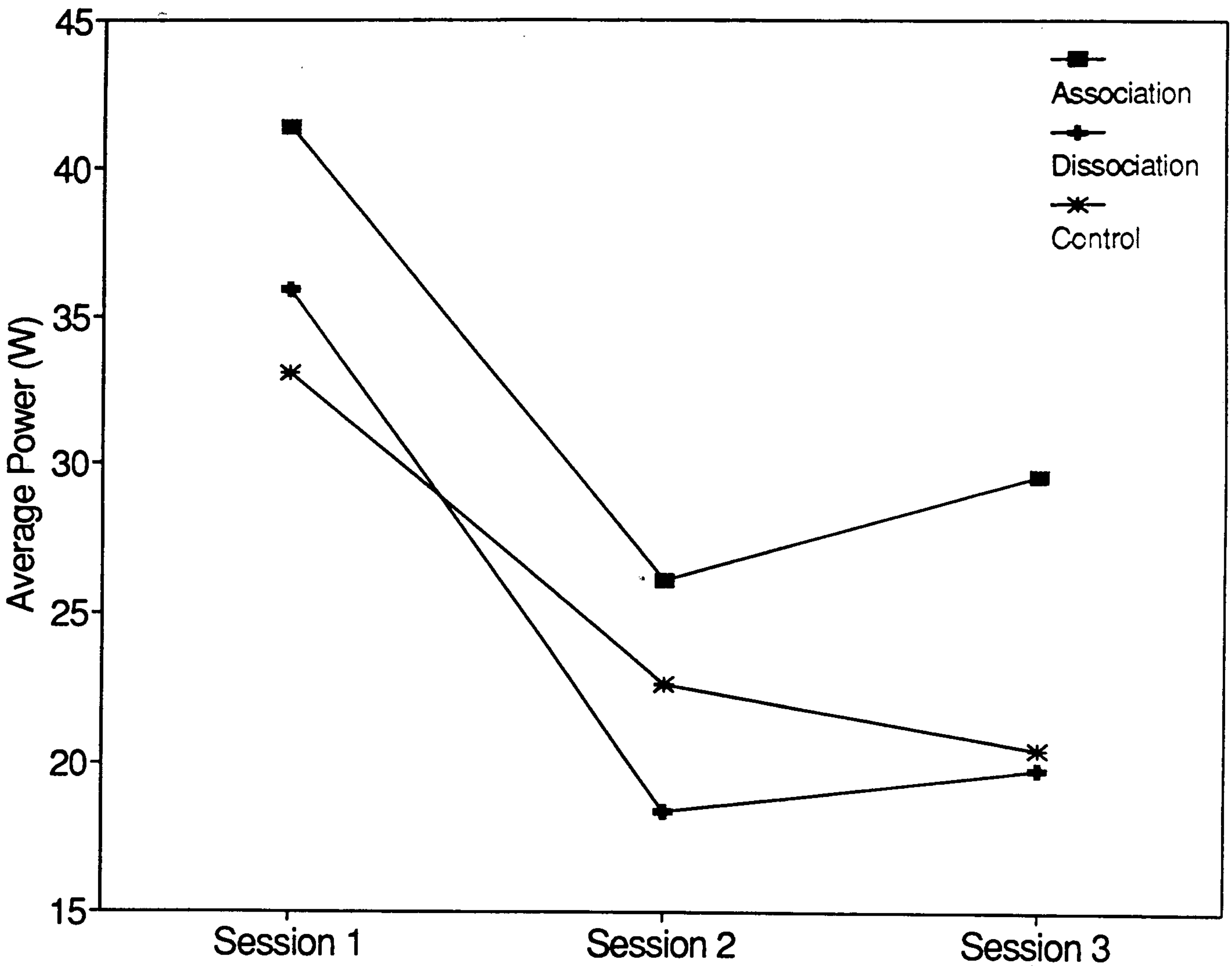

Figure 9. Means for average power of the hamstrings at 40 repetitions

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group TW for 40 repetitions showed a significant session effect ($F = 30.09$, $p < .05$). The means, standard deviations, and F values are presented in Table 5. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 11).

A 3 (Group) x 3 (Session) mixed model ANOVA on the quadricep muscle group AP for 40 repetitions showed a significant session effect ($F = 22.77$, $p < .05$). The means, standard deviations, and F values are presented in Table 5. Post hoc Tukey analyses revealed that there were significant differences between Session 1 and Sessions 2 and 3 (see Figure 12).

These findings led to the non-acceptance of the following research hypotheses: that subjects in the association group will significantly increase their performance scores (as measured by PT, TW, and AP) from Session 2 to Session 3, and that subjects in the dissociation group will significantly increase their performance scores (as measured by PT, TW, and AP) from Session 2 to Session 3. These findings led to the acceptance of the research hypothesis that subjects in the control group will not

Table 5

Means, Standard Deviations, and ANOVAs for Peak Torque (PT), Total Work (TW), and Average Power (AP) of the Quadriceps at 40 Repetitions

	M	SD	F
PT (Nm)			
Group Effect			
Association	199.09	45.08	
Dissociation	172.60	48.67	1.02
Control	173.31	53.84	
Time Effect			
Session 1	210.19	45.34	
Session 2	165.11	52.21	27.97*
Session 3	170.11	52.80	
Interaction			2.31
TW (J)			
Group Effect			
Association	5158.03	1611.30	
Dissociation	4490.16	1375.50	1.07
Control	4325.07	1162.20	

(table continues)

	M	SD	F
Time Effect			
Session 1	5566.61	1269.99	
Session 2	4214.07	1511.91	30.09*
Session 3	4192.58	1491.51	
Interaction			1.89
AP (W)			
Group Effect			
Association	67.31	21.60	
Dissociation	59.96	18.30	0.75
Control	57.93	15.88	
Time Effect			
Session 1	71.93	16.11	
Session 2	55.83	21.13	22.77*
Session 3	57.43	19.76	
Interaction			1.72

Note. Peak torque is measured in newton-meters (Nm); total work is measured in joules (J); and average power is measured in watts (W).

* $p < .05$.

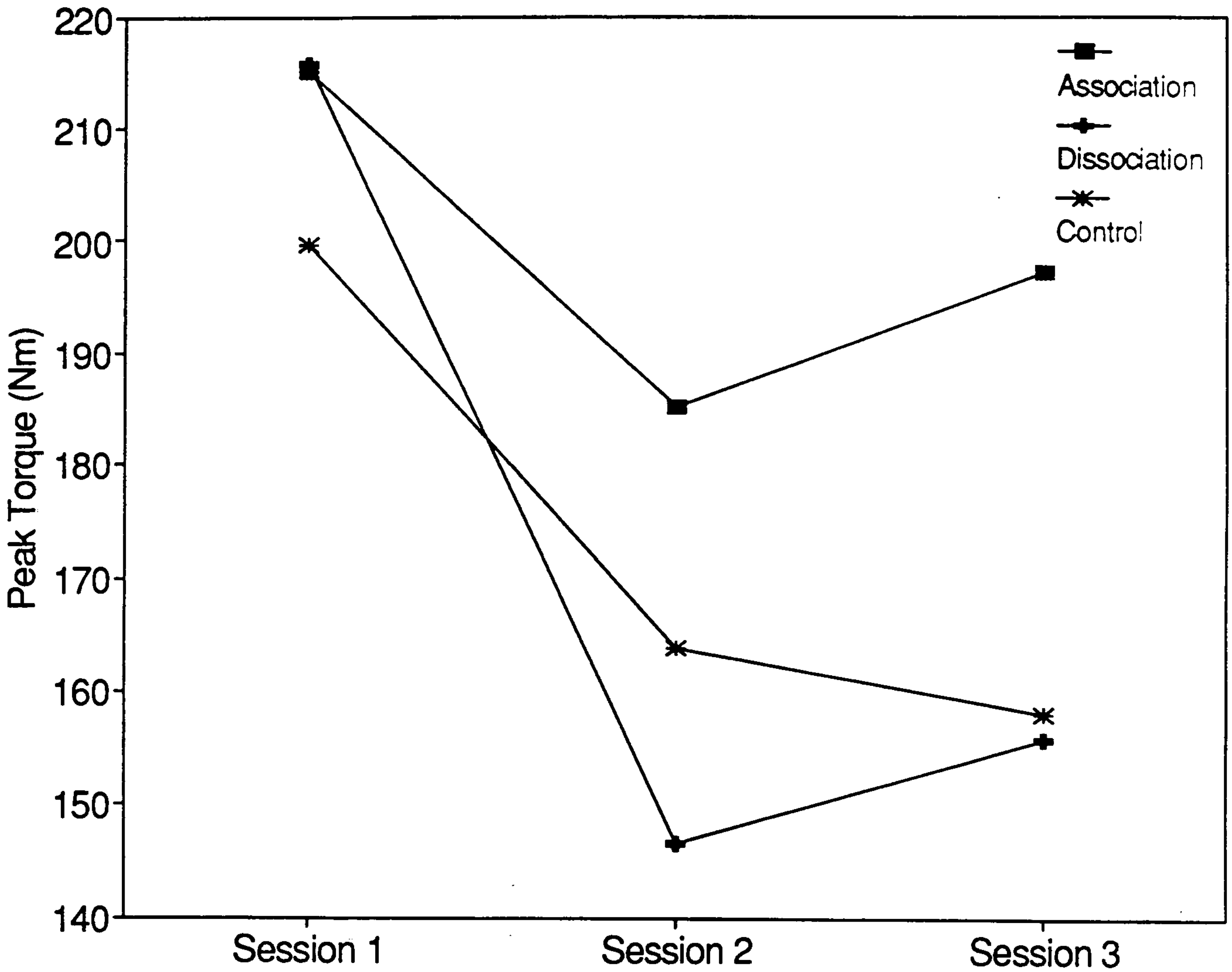

Figure 10. Means for peak torque of the quadriceps at 40 repetitions.

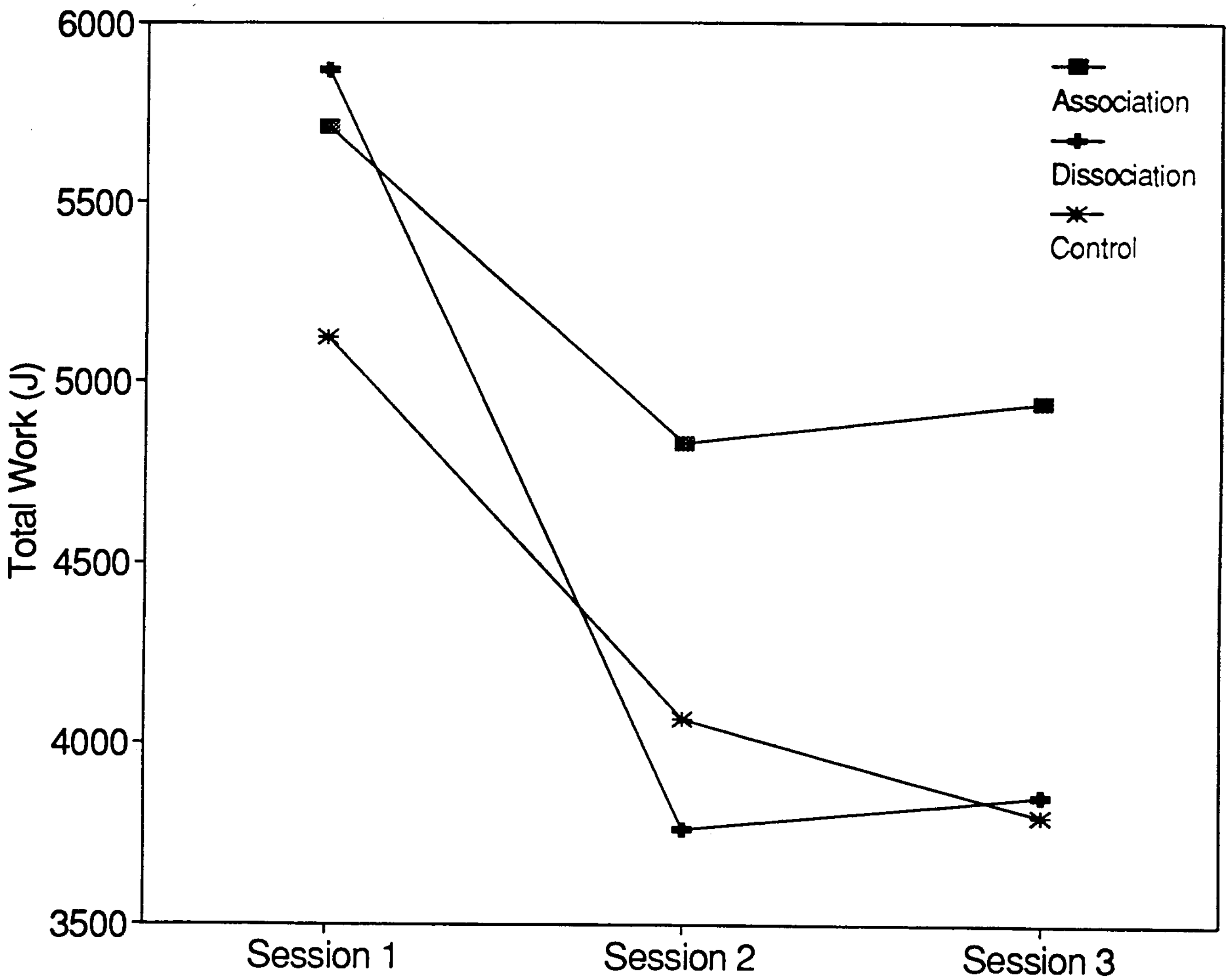

Figure 11. Means for total work of the quadriceps at 40 repetitions.

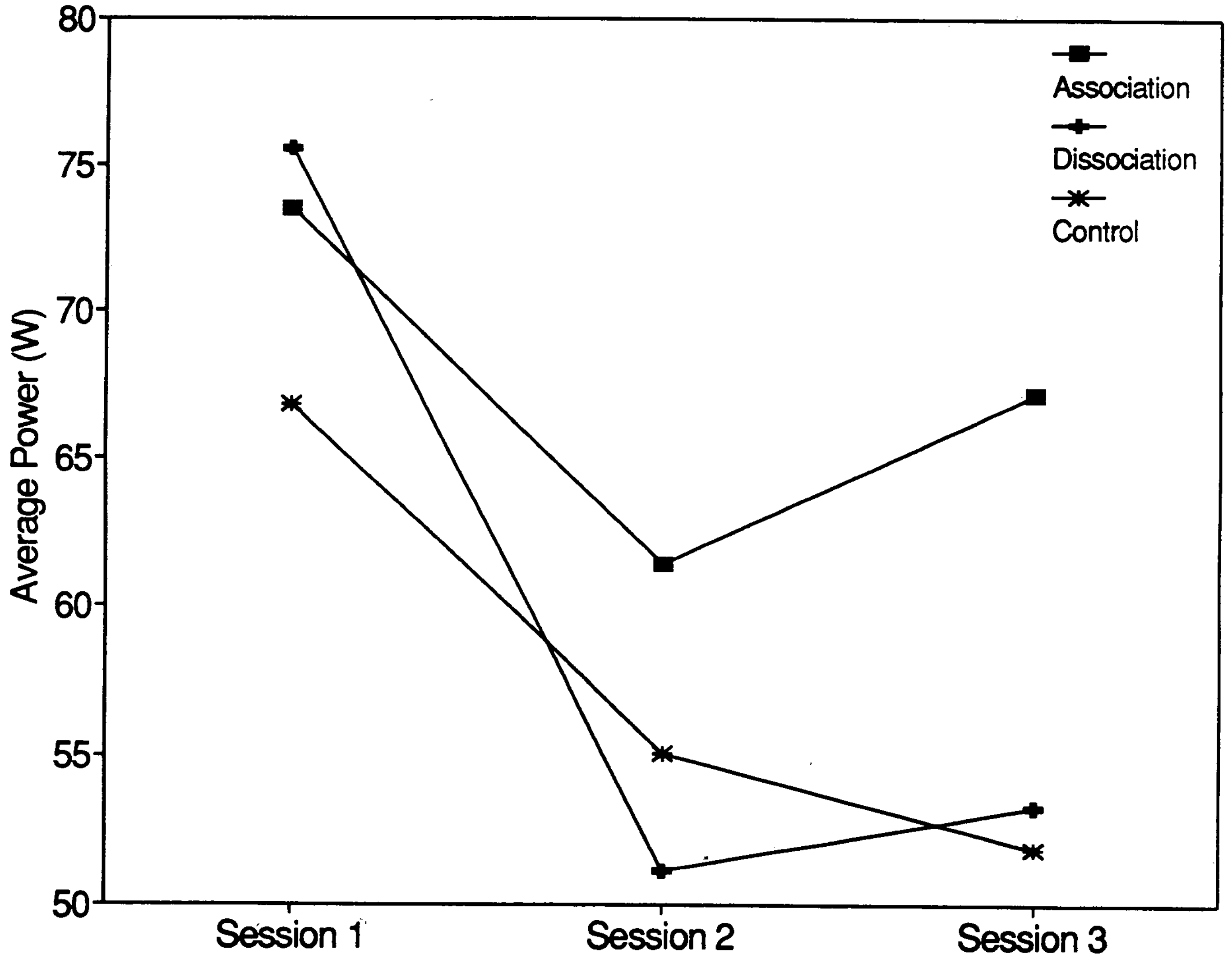

Figure 12. Means for average power of the quadriceps at 40 repetitions.

significantly increase their performance scores (as measured by PT, TW, and AP) from Session 2 to Session 3.

Analysis of SAT and Pre-PPS (Sessions 2 and 3)

ANOVAs were conducted to determine whether there were group differences on the SAT in Sessions 2 and 3. There were no significant differences for the SAT in Session 2 ($F = 1.94$, $p > .05$) or Session 3 ($F = 1.57$, $p > .05$). In fact, the scores on the SAT in Sessions 2 and 3 indicated that anxiety was most likely not a contributing factor to the decreased performance scores in Sessions 2 and 3 from Session 1. The SAT score could range from a minimum of 10 (low anxiety level) to 40 (high anxiety level). Thus, a low score indicated low anxiety. For the entire sample, the average SAT score in Session 1 was 16.91 ($SD = 4.97$); in Session 2 it was 15.83 ($SD = 4.93$); and in Session 3 it was 13.90 ($SD = 4.25$). Based on these SAT scores, subjects' anxiety seemed to be slightly lower in each session because the lower the SAT score, the lower the anxiety level. Thus, it would appear that the decreased performance scores in Sessions 2 and 3 from Session 1 were not affected by anxiety (as measured by the SAT).

ANOVAs also determined that there were no group differences on the Pre-PPS in Sessions 2 and 3. The groups did not differ significantly on the Pre-PPS in Session 2 (F = 1.07, p > .05) or Session 3 (F = 1.03, p > .05). The mean Pre-PPS score in Session 2 was 2.07 (SD = 0.91) and in Session 3 it was 2.9 (SD = 0.78). This indicated that pre-perception of performance for the whole population increased from "somewhat weaker" (75%) in Session 2 to almost "slightly weaker" (90%) in Session 3. Thus, it would appear that the decreased performance scores in Sessions 2 and 3 from Session 1 were not affected by subjects' pre-perception of performance because the sample perceived that they would be a little stronger in the third testing session (3 hr after the second testing session).

The mean Pre-PPS scores by group for Sessions 2 and 3 are reported in Table 6. These scores show the mean Pre-PPS score for the association group (2.20) and dissociation group (1.70) in Session 2 increased to 3.20 and 2.90, respectively, in Session 3. These apparent increased scores indicate that these subjects perceived they would perform better in the third session compared to the second session. The mean Pre-PPS scores for the control group showed little change between Sessions 2 (2.20) and 3 (2.70). Therefore, as the Pre-PPS scores increased in Session 3 from Session 2, it would appear that the performance decline that occurred in these two

Table 6

Mean Scores of Muscle Soreness Scale (MSS), Pre-Perception of Performance (Pre-PPS), and Post-Perception of Performance (Post-PPS) in Sessions 2 and 3

	MSS	Pre-PPS	Post-PPS
Session 2			
Sample	4.73	2.07	2.17
Association	4.30	2.20	2.60
Dissociation	4.90	1.70	1.90
Control	5.00	2.30	2.00
Session 3			
Sample	4.87	2.93	3.97
Association	4.30	3.20	4.80
Dissociation	5.30	2.90	4.40
Control	5.00	2.70	2.60

sessions, compared to Session 1, was not due to subjects perceiving that they would be weaker in the final testing session.

These findings led to the acceptance of the hypothesis that muscle soreness, and not anxiety or pre-perception of performance, will be closely related to the decreased performance scores in Sessions 2 and 3 from Session 1.

Comparison of the MSS, Pre-PPS, and Post-PPS Groups for PT, TW, and AP over the Three Testing Sessions

Univariate ANOVAs were conducted to determine whether there were MSS, Pre-PPS, and Post-PPS differences, as measured in Session 2, for PT, TW, and AP. For the MSS, responses from Session 2 were condensed into 2 low and high categories. Individuals with MSS responses of 2, 3, and 4 were assigned to the "low" category and those with responses of 5, 6, and 7 were assigned to the "high" category. Subjects scoring response 1 ("no pain") in Session 2 were excused from the investigation. For the Pre-PPS and Post-PPS, responses from Session 2 were also condensed into the two categories of low and high. Responses 1, 2, 3, and 4 became "low" and responses 5, 6, and 7 became "high."

Six 2 (MSS) x 2 (Pre-PPS) x 2 (Post-PPS) x 3 (Session) mixed model ANOVAs were conducted for both 10 repetitions and 40 repetition tests for the hamstring and quadricep muscle groups. The dependent variables included PT, TW, and AP. Every ANOVA, except for the quadricep muscle group for the 40 repetitions test for TW and AP, showed no significant interaction or group effects for MSS, Pre-PPS, and Post-PPS, but there were significant session differences. The performance scores of PT, TW, and AP differed significantly between Session 1 and Sessions 2 and 3. This has been noted in a previous section. The ANOVAs of the quadricep muscle group for 40 repetitions for TW and AP showed no significant interaction, group, nor session effect.

Six 2 (MSS) x 2 (Post-PPS) x 3 (Session) mixed model ANOVAs were then conducted for both 10 repetitions and 40 repetitions tests for the hamstring and quadricep muscle groups. The dependent variables included PT, TW, and AP. None of the interaction or group main effects were significant, but there were significant session main effects. The performance scores of PT, TW, and AP differed significantly from Session 1 to 2 and Session 1 to 3, but not from Session 2 to 3. This has been noted in a previous section.

The mean MSS, Pre-PPS, and Post-PPS scores for the whole sample and for each group in Session 2 are presented in Table 6. These findings led to the acceptance of the research hypothesis that there will be no differences among the MSS, Pre-PPS, and Post-PPS categories as measured in Session 2.

Analyses of the MSS, Pre-PPS, and Post-PPS in Session 3

ANOVAs were conducted to determine whether there were group differences for MSS, Pre-PPS, and Post-PPS in Session 3. The mean MSS, Pre-PPS, and Post-PPS scores for the whole sample and for each group in Session 3 are presented in Table 6. The groups did not differ significantly on MSS (F = 1.96, p > .05) or on Pre-PPS (F = 1.03, p > .05). The groups did differ significantly on Post-PPS (F = 5.24, p < .05) (see Figure 13). ANOVA revealed that there was a significant difference (p < .05) between the association and the control group. The alpha value for the difference between the dissociation group and the control group equalled .052. The .05 alpha level is a good fail-safe standard because it is both convenient and stringent enough to safeguard against declaring an insignificant result as significant. Yet, dichotomous significance has no ontological basis (Rosnow & Rosenthal, 1989). Given the small sample size (N = 30) and the smaller group size (n = 10), an alpha level equalling .052 is probably as significant as an alpha level of .05. The difference between the two values is minute. Therefore, the alpha level of .052 for the difference between the dissociation and control groups

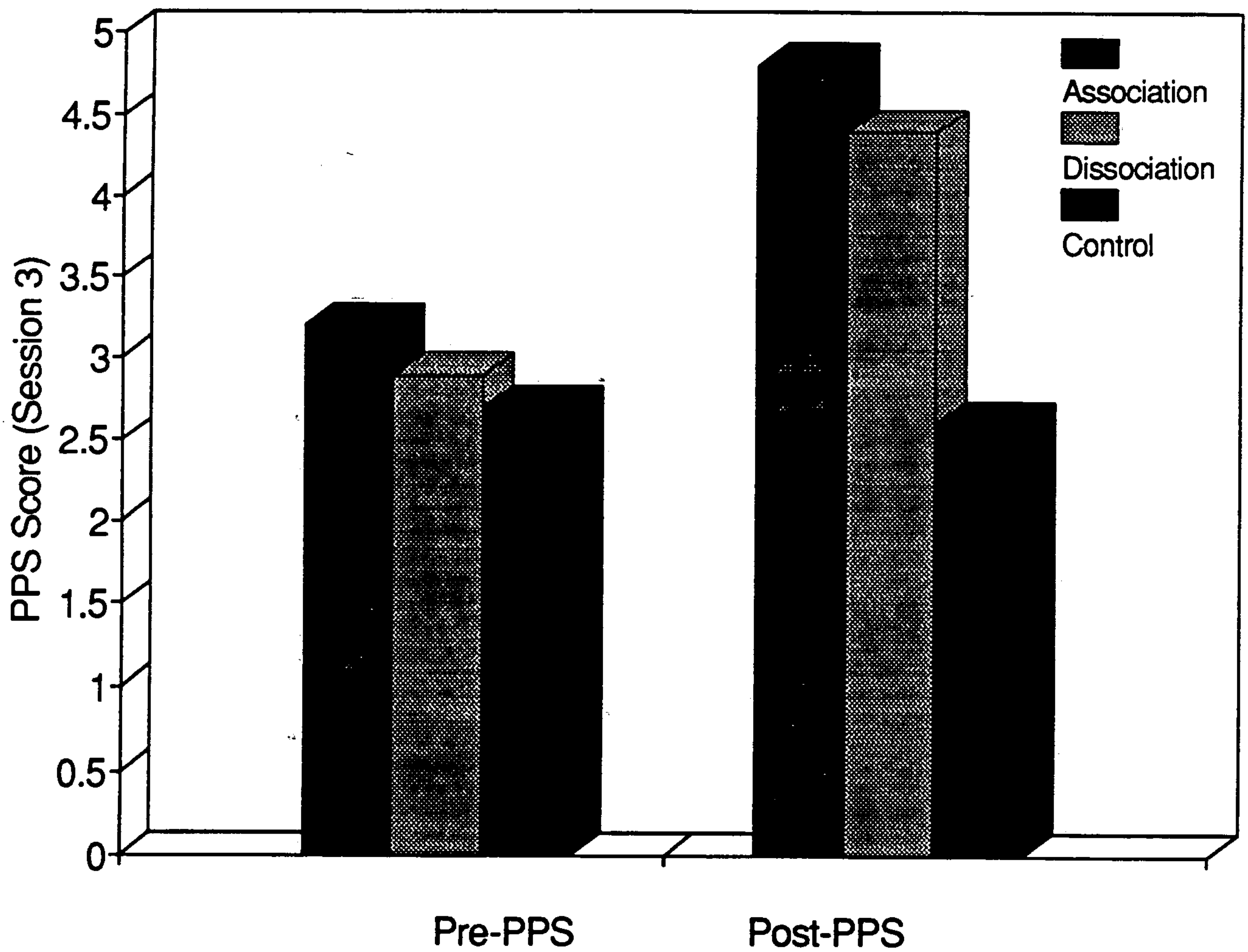

Figure 13. Pre-perception of performance (Pre-PPS) and post-perception of performance (Post-PPS) scores in Session 3.

was accepted as significant.

Post hoc Tukey analyses revealed that the significant Post-PPS differences occurred between the control group and both of the treatment groups (see Figure 13). The Post-PPS was administered directly after testing on the Biodex. Both the association and dissociation group scores indicate that they perceived they performed significantly better in this session compared to the second session and were therefore able to increase their tolerance to their pain level.

These findings led to the acceptance of the research hypotheses that subjects in both the association and dissociation groups will show significant increases in their Post-PPS scores in Session 3 compared to the scores of subjects in the control group, thereby indicating significant increases in their pain tolerance levels.

Analysis of SEQ Item Responses

An analysis of the SEQ item responses was completed as a manipulation check to determine the degree to which the subjects complied with the instructions on the tape they listened to during Session 3. Subjects rated each statement on a 6-point scale: strongly disagree, disagree, not sure, agree, strongly agree, and not applicable. Response 3 (not sure) was to be used if the subject could not make a better assessment,

Table 7

Analysis of Strategy Evaluation Questionnaire (SEQ) Item Responses by Group

Item Number	SD	D	NS	A	SA	NA
	Response Percentage					
Association Group						
1				50	50	
2				70	30	
3		10	30	40	20	
4			10	60	30	
5	10	50		20	20	
6	20	20		30	30	
7	10	30	10	50		
Dissociation Group						
1	10		20	20	50	
2		10	20	50	20	
3		10	20	40	30	
4				30	70	
5	20	20		40	20	

(table continues)

Item Number	Response Percentage SD	D	NS	A	SA	NA
6	10	50		10	30	
7	20	50		30		
Control Group						
1						100
2						100
3						100
4						100
5		70	10	20		
6		20	10	70		
7						100

Note. Abbreviations used: SD = Strongly Disagree, D = Disagree, NS = Not Sure, A = Agree, SA = Strongly Agree, NA = Not Applicable.

and response 6 (not applicable) was to be used by subjects in the control group for item numbers 1-4, 6-8, and 10. Subjects' responses (by group) are presented in Table 7.

Subjects in the association group were in 100% agreement and subjects in the dissociation group were in 70% agreement that the strategy helped to increase their pain tolerance and performance. There was 60% agreement in the association group and 70% agreement in the dissociation group that, with practice, subjects could further increase their pain tolerance. There was 90% agreement in the association group and 100% agreement in the dissociation group that the strategy was simple to use. Within the association group, 40% felt they were usually focusers and, therefore, used an association-type strategy when injured and/or in pain. The other 60% felt they were usually distractors and, therefore, used a dissociation-type strategy when injured and/or in pain. In the dissociation group, 60% felt they generally used an association strategy when injured and/or in pain and 40% felt they generally used a dissociation strategy when injured and/or in pain. In the control group, 20% felt they generally used an association strategy when injured and in pain, 70% felt they generally used a dissociation strategy when injured

Table 8

Predominant Thoughts During Testing Session 3 by Group

	Response Percentage
Association Group	
Focusing on the area and muscles where the pain was	60
No pain, No gain!	10
Decreasing the frame size	30
Concentrating on a maximal effort	50
Using pain to create strength	40
Pain = Energy	20
Dissociation Group	
Counting number of repetitions	10
Using a word or phrase (i.e., Explode! Power! Push It! Let's Go!)	80
When will this be over?	20
This is painful!	20
Focusing on breathing	10

(table continues)

	Response Percentage
Control Group	
Ouch! Pain!	70
When will this be over?	50
What will I do later?	40
Try harder	20

Note. Each subject listed more than one thought during this testing session.

and/or in pain, and 10% were not sure what, if any, strategy they used.

In the association group, the mean percentage of the testing session spent actually utilizing the strategy was 80.5% (SD = 6.85%), and the dissociation group's mean percentage was 81.90% (SD= 16.24%). However, this is not to suggest that attention on the respective cognitive strategies was unwavering because 50% of the association group and 30% of the dissociation group indicated that they had lapses in concentration while using their strategies. There was 100% agreement in both the association and dissociation groups that they would use their respective strategy in the future.

The thoughts that occupied subjects in the third testing session are summarized by group in Table 8. Each subject listed more than one thought. The most frequent thoughts among those in the association group were "focusing on the area and muscles where the pain was centered," "concentrating on a maximal effort," "using pain to create strength," and "decreasing the frame size." Among the dissociation group, the most frequent thoughts were a word or a phrase, such as "Explode!" "Power!" and "Let's Go!" repeated with each repetition. Among the control group, the most frequent thoughts were "What will I do later?", "When will this be over?", and "Ouch!, Pain!".

Summary

Intraclass correlation coefficients were calculated to determine the internal consistency of Biodex trials of both quadricep and hamstring muscle groups. The mean R score for the two sets of 10 repetitions was .97, therefore all scores of each performance variable from the two sets were used. The mean R score for the two sets of 40 repetitions was .93, therefore only the scores from the first set of 40 repetitions was used.

Results of mixed model ANOVAs, and further analyses where required, on each performance variable established that there was a significant session (i.e., time) main effect. There was a significant difference from Session 1 to 2 and Session 1 to 3, but not from Session 2 to 3. Subjects in neither the association nor dissociation group significantly increased their performance scores (as measured by PT, TW, and AP) from Session 2 to Session 3.

Anxiety did not change from Session 1 to Sessions 2 and 3, and pre-perception of performance did not change from Session 2 to 3. Therefore, the SAT and Pre-PPS did not likely affect the dramatically decresed performance scores in Sessions 2 and 3. The MSS, however, rose in concert with the falling performance scores and was most likely causally related to the drop in performance. Therefore, the research hypothesis, that muscle soreness, and not anxiety or pre-perception of performance, was the major cause of the decreased performance scores in Sessions 2 and 3 compared to Session 1, was accepted.

ANOVAs were used to determine that there were no MSS, Pre-PPS, or Post-PPS differences, as measured in Session 2, for PT, TW, and AP. Mixed model ANOVAs determined that there were no significant interaction or group main effects for the MSS and Post-PPS, as measured in Session 2, but that there were significant session effects for PT, TW, and AP. These results led to the acceptance of the research hypothesis that there will be no significant differences among the MSS, Pre-PPS, and Post-PPS categories as measured in Session 2.

ANOVAs determined that there were no group differences for the MSS and Pre-PPS in Session 3, but there were group differences for the Post-PPS in Session 3. Further analyses revealed that the association group scored significantly higher than the control group on the Post-PPS. These results led to the acceptance of the research hypothesis that subjects in the association group will show a significant increase in their

Post-PPS scores in Session 3 compared to the scores of subjects in the control group, thereby demonstrating a significant increase in their pain tolerance levels. These findings led to the non-acceptance of the hypothesis that subjects in the dissociation group will show a significant increase in their Post-PPS scores in Session 3 compared to the scores of the control group, thereby demonstrating no significant increase in their pain tolerance levels.

Item responses to the SEQ were described by group. The majority of subjects in both the association and dissociation groups utilized their respective strategy and believed that it was effective in increasing both their pain tolerance levels and performance scores. All subjects indicated they would use their respective strategy in the future.

Chapter 5

DISCUSSION OF RESULTS

Performance of athletes can be severely affected when they are injured and in pain, both in the sporting arena and when undergoing sports injury rehabilitation. The ability to tolerate pain varies from individual to individual (Melzack, 1973), and rehabilitation can be a lengthy process should the injured athlete be unable to effectively deal with the emotions and pain that are associated with injury. Association and dissociation are two cognitive strategies that individuals use to cope with pain. It has been shown previously that cognitive strategies increase pain tolerance levels (e.g., Chapman, 1980; Friedman et al., 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). Cognitive strategies may increase perception of performance as well as actual performance because these strategies affect the strong mental component that is involved in pain.

This investigation was designed to investigate the effects of two cognitive strategies, association and dissociation, on pain tolerance and performance (both actual and perceived) in athletes with muscle soreness/damage. The results presented in chapter 4 will be discussed in this chapter.

This chapter's contents will focus on the following topics: (a) effectiveness of soreness induction procedure as a pain model, (b) effectiveness of cognitive strategies, (c) appropriateness of cognitive strategies in rehabilitation, and (d) summary.

Effectiveness of Soreness Induction Procedure as a Pain Model

The experimental protocol of this study necessitated that subjects experience muscle soreness/damage. Significant declines in strength performance following Session 1 were reported for all variables. Clarkson et al. (1992) reported that, after unaccustomed eccentric exercise, there is a dramatic strength loss of over 50% immediately after exercise, and strength is gradually, but slowly, restored so that by 10 days after exercise a deficit still remains. It is apparent that strength declined by about 40% by the second testing session, which occurred 48 hr after the soreness induction procedure. Therefore, it is quite apparent that the manipulation to induce soreness and probably muscle damage was successful (see Figures 1-12).

It was possible that subjects with a high anxiety level may have intensified their ratings of muscle soreness and strength performance in Sessions 2 and 3. However, this was not likely the case because subjects' anxiety did not increase, and in fact slightly decreased, as subjects progressed from Session 1 to 3. There were no group differences on the SAT in each session, and the scores indicate that all subjects had low levels of anxiety in each session. In addition, as there were no group differences on the MSS, it can be assumed that groups had a random mix of high and low pain tolerators. Soreness levels normally increase in intensity in the first 24 hr after exercise, peak from 24-72 hr, and are gone by 5-7 days postexercise (Armstrong, 1984). Sessions 2 and 3 occurred 48 hr and 51 hr after Session 1, respectively, and muscle soreness would be at or near its peak in these sessions. The mean scores for the MSS in Session 2 indicated that muscle soreness for the sample was between the levels of "more than slight pain" and "painful." These levels of soreness mirror the descriptions of exercise-induced muscle soreness by Armstrong (1984) and Clarkson et al. (1992). These descriptions of muscle soreness/damage can be summarized as feeling "stiff" or "tender" in the affected area, and this may vary from slight stiffness in the muscles to severe debilitating pain that interferes with movement. This substantial rise in soreness seems closely related to the drop in performance experienced by all subjects.

In addition, it was possible that, because subjects rated their level of muscle soreness and perception of performance prior to testing, this may have differentially affected their performance. Attaching a numerical value (a cognitive decision) by reading an appropriate description of their muscle soreness, and predicting their strength loss due to their muscle soreness, could have accentuated the intensity of their soreness. This, in turn, could then cause subjects to perform at a reduced level because the soreness may have been magnified. Because ANOVAs revealed no group differences on the MSS and Pre-PPS for PT, TW, and AP, it can be assumed that subjects' rating of muscle soreness/damage did not then adversely affect their performance. The same occurred in Session 3. This indicates that the major cause for the decreased performance scores was actual muscle soreness (as against the process of rating muscle soreness and pre-perception of performance).

Effectiveness of Cognitive Strategies

Many studies have found that cognitive strategies increase pain tolerance levels and performance (e.g., Chapman, 1980; Friedman et al., 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). The concept of pain is closely linked to that of perception.

Technically, pain does not exist until the cerebral cortex receives information that evokes pain (Bogduk, 1991), and should attention be intensely focused on other stimuli, it is possible that the effects of noxious stimulation may be reduced or even go unnoticed (Melzack, 1973). Cognitive strategies attempt to monopolize the strong mental component involved in pain (Gauron & Bowers, 1986) by focusing attention solely on the demands of the strategy, and not on the stimulation that is causing and/or intensifying the pain (i.e., the strength test).

Session 3 was when the intervention was given to the two experimental groups. It was hypothesized that these strategies would significantly increase the performance scores of the association and dissociation groups, while the scores of the control group would not significantly change. There was a significant difference in performance scores from Sessions 1 to 3, and this again indicated that muscle soreness/damage had occurred following Session 1. However, there were no significant differences from Sessions 2 to 3, nor between groups in Session 3. Therefore, the cognitive strategies did not significantly enhance performance.

However, close examination of Figures 1-12 reveals a trend in regards to performance. The performance variables of

PT of both muscle groups for both 10 and 40 repetitions and TW and AP of both muscle groups for 40 repetitions illustrate that the scores of the association and dissociation groups did increase on average approximately 10-15% in Session 3 (see Figures 1, 4, 7-12). This increase was not large enough to be significantly different from the control group, but it indicates that the strategies tended to increase the scores of these variables.

The association strategy involved subjects changing their appraisal of the pain (see Appendix I), requiring them to focus all of their attention on their feelings. The strategy emphasized that subjects utilize the pain as a source of energy (i.e., strength) and increase their performance from the previous session. This meant that, cognitively, subjects channelled their appraisal of the pain into a positive (instead of a negative) aspect, and it became a source of power rather than one of distress. The dissociation strategy (see Appendix I) emphasized that subjects refocus their attention away from the pain by concentrating on internal distractors such as repeating a word or a phrase, counting repetitions, or amplifying breathing. Dissociation allows distraction from the feelings of distress associated with pain (Spink, 1988).

Research on mental methods of control has shown that both dissociation and association reduce the experience of stress before the event occurs, ameliorate distress during the actual event, and reduce the often debilitating aftereffects of stress (Taylor, 1989). Taylor claimed that those who cope with a stressful event by using association may show distress beforehand but deal more successfully with the event and its aftermath. Similarly, this investigation revealed that the association group tended to increase all their scores for each performance variable from Session 2 to 3, thus supporting this part of Taylor's claim. Taylor also stated that dissociation seems to be particularly helpful in improving coping before and during an event but is not as successful in reducing stress toward the end of a stressful event or afterward. Therefore, in this investigation, one may have expected all the scores in the dissociation group to have decreased from Session 2 to 3 in the longer sets of exercise (i.e., 40 repetitions). However, the data trends of this investigation reveal a different conclusion. Figures 2, 3, 5, and 6 illustrate that, in the longer sets of exercises, those in the dissociation group tended to increase scores from Session 2 to 3, but, in the earlier and shorter sets of exercise (i.e., 10 repetitions), scores tended to be lower, contradicting this part of Taylor's assertion.

This raises the question of which strategy is more successful: dissociation or association? It is possible that there is no real answer because both strategies are efforts to control the aversive stimulus. Dissociation attempts to control the emotional response while association attempts to directly tackle and restructure the aversive stimulation. Perhaps by working in tandem, these strategies can maximally reduce a person's experience of loss of control and thereby lessen the stress of the event (Taylor, 1989).

It has been shown that individuals can often tolerate extreme distress if they believe they have the ability to control the source of that distress (Taylor, 1989). By possibly elevating individuals' sense of coping self-efficacy with the strategies, their resourcefulness and persistence in applying the strategies is promoted. Therefore, their attentional deployment and cognitive appraisal reduces the distressing anticipations (i.e., fear) that can produce anxiety and, therefore, exacerbate pain (Williams & Kinney, 1991).

The Post-PPS revealed that the association and dissociation groups perceived that they had significantly enhanced their performance while utilizing the strategies, compared to the control group. Thus, the results show that, while performance did not significantly improve, those in the treatment groups perceived that their performance had significantly improved. Accordingly, it would appear that their attention was successfully deployed to the tasks of the strategy. All of the subjects in the association group and 70% of subjects in the dissociation group believed that their strategy helped them increase their pain tolerance and their performance (see Tables 7 and 8). These subjects perceived that their capacity to tolerate pain had increased and their strength performance had increased by utilizing their strategy. They believed that the strategies had worked. However, the results showed that performance did not significantly increase while utilizing the strategies. Yet, the adequacy of a process cannot be judged solely on the basis of its outcome (Taylor, 1989). It appears that subjects' sense of self-efficacy in tolerating pain and in increasing performance was enhanced by the strategies. This may be important because self-efficacy is a powerful predictor of sports injury rehabilitation adherence (Fisher, 1990). Fisher pointed out that adherers to sports injury rehabilitation believe that they were capable of meeting the demands of the rehabilitation regimen (i.e., type, duration, frequency, intensity) in a manner that will lead to a return to functional capacity. Perhaps these strategies can enhance injured athletes' sense of self-efficacy to tolerate pain and alter performance, thereby promoting higher adherence levels to sports injury rehabilitation.

Related to this sense of coping self-efficacy is Rotter's (1966) proposal that there are differences in individuals' locus of control. Athletes expect their sports injury rehabilitation to be influenced by personal actions (internal locus of control) or by either the actions of others or by chance occurrence (external locus of control). For those who have predominantly an external locus of control, it is possible that their rehabilitation may be lengthened due to their inability to adhere to the program outside of scheduled sessions because they are dependent on the actions of the clinician. The opposite may be surmised for those who have predominantly an internal locus of control; their rehabilitation may be quickened due to their adherence to the program outside of scheduled sessions because they are dependent on personal actions, rather than the actions of the clinician. Therefore, what is significant is the importance of beliefs concerning control, not simply whether control is in fact present or absent in these potentially stressful treatment situations (Taylor, 1989). After utilizing their strategies, subjects in the association and dissociation groups reported that they perceived that their performance was significantly enhanced--even though it was not.

This, in turn, leads to another concept of efficacy--illusory efficacy. The strategies provided subjects with the confidence that they could accomplish the set task and the belief and optimism that they would succeed at the task (Taylor, 1989). Illusory efficacy means that subjects believe or perceive that they have successfully accomplished the set task even if they have not. This occurred with the association and dissociation groups in the present study. They perceived that they had significantly increased their strength by utilizing the strategy, but in reality they had not. Why was belief not enough to promote performance changes in a statistically significant way?

It is possible that training in effectively using the cognitive strategies is required to increase both pain tolerance levels and performance. Various studies have trained their subjects how to effectively utilize the respective cognitive strategy in pain tolerance experiments before testing (e.g., Gauron & Bowers, 1986; Spink, 1988; Thorn & Williams, 1989). Greater experience at using a cognitive strategy should enhance the effectiveness of the strategy. This investigation allowed subjects to listen to their strategy only three times during the testing. There was no practice or indication prior to the final testing session that they would be asked to utilize a strategy. It is possible that both strategies may have significantly increased performance scores had subjects been trained with the strategy.

In addition, these strategies only utilized one of the three general responses to pain. In this investigation, feelings of apprehension and fear of the onset of pain may exist (an affective component); thoughts of "Why am I doing this?" or "This is going to hurt" may exist (a cognitive component); followed by an unwillingness to offer a maximum effort (a behavioral component). Had the strategies been designed to address each of these responses, it is possible that performance may have increased. Other studies, including this one, tend to only address the affective component.

Another point to consider is that earlier pain induction techniques used more traditional methods of inducing pain like the cold pressor test or ischemic pain (e.g., Chapman, 1980; Fernandez, 1989; Friedman et al., 1985; Gauron & Bowers, 1986; Pennebaker & Lightner, 1980; Thorn & Williams, 1989). However, one limitation of these techniques is that they are inherently safe and subjects know the test can be terminated at any time. Not only will the test be terminated but the pain experienced will also be terminated because the pain is due only to the noxious stimulation present.

However, exercise-induced muscle soreness/damage cannot be terminated on command. The pain, stiffness, prolonged reduction in muscle strength, and decreased range of motion that appear 24-48 hr after strenuous eccentric exercise does not fully subside until 8-10 days after the initial bout of exercise (Clarkson et al., 1992). Thus, subjects experience long lasting, real life pain, and their pain tolerance and performance levels would not be limited by the knowledge that terminating the test would terminate their pain. Even though at rest there is virtually no pain, because muscle soreness/damage was induced in the lower extremity, pain cannot be avoided because ambulatory activities dominate daily activities. Perhaps these cognitive strategies are not as effective with acute, intense pain that does not terminate at the end of the test as earlier research into pain tolerance and performance has found.

Most of the studies that have investigated pain tolerance and performance with athletes have used an endurance-type event of a 30-min run to test the effectiveness of cognitive strategies (e.g., Morgan, 1978; Morgan & Pollock, 1977; Pennebaker & Lightner, 1980; Sachs & Sachs, 1981; Spink, 1988; Weinberg et al., 1984) Thus, the pain generally disappears when the test is completed. The pain associated with running can dissipate quickly once the run is completed, especially when the running time is 30 min and not a marathon. Unlike the 30-min run, the pain associated with exercise-induced muscle soreness/damage is acute in nature, hinders movement, and can take up to 7-10 days to disappear (Armstrong, 1984; Clarkson et al., 1992). Perhaps this helps to explain why performance scores did not significantly increase in this investigation.

Appropriateness of Cognitive Strategies in Rehabilitation

Research has indicated that both athletic trainers and injured athletes agree that accurate appraisal of pain and subsequent focusing of attention are important factors in maintaining rehabilitation adherence (Fisher & Hoisington, 1993). Some athletes may drop out of injury rehabilitation programs due to a low pain tolerance level, their belief that they cannot tolerate the pain, and/or their fear of the pain they are about to experience in the treatment of their injuries. Armstrong (1984) found that one of the sensations of exercise-induced muscle soreness/damage was sensitivity within the affected muscles, especially upon palpation or movement. Similarly, in this investigation, subjects indicated that muscle soreness was much worse when the injured muscles were in movement, whereas at rest there was virtually no pain. Because the affected muscles were in the lower extremity, all ambulatory activities caused pain. Thus, when subjects rated their Pre-PPS, they knew that the movement required in the strength test would cause considerable pain. The cognitive strategies attempted to focus attention away from fear of the onset of pain.

In Session 2 there was a retest of muscle strength following the induction of muscle soreness/damage, and subjects attended Session 3 3 hr after this test. Session 2 may have sensitized subjects to the likelihood of pain because this was the first intense test of performance since soreness was induced 48 hr earlier. It is possible that the strategies changed subjects' perceptions of the situation by providing efficacy expectations, thereby alleviating doubts and fears about the pain they knew would commence with the strength test (Friedman et al., 1985).

Focusing attention away from the pain can be a positive component when the injured athlete has low pain tolerance. Fisher et al. (1988) found that low pain tolerance characterized injured athletes who tended to adhere less to rehabilitation programs, and therefore these athletes seemed less capable or willing to work through the pain. The sense of illusory efficacy that the strategy appeared to provide can give confidence to such athletes and help them complete their rehabilitation program at the desired exertion/effort level. In addition, it is possible that many of the devastating emotions (i.e., helplessness, depression, anger, loss of control, and so on) that are associated with a debilitating injury (Weiss & Troxel, 1986) may be lessened by illusory efficacy. Should these strategies provide positive feelings contrasted with the negative feelings normally associated with injury, they could be very useful in rehabilitation.

However, athletes with a high pain tolerance level may actually increase the severity of their injury by utilizing cognitive strategies. Pain is associated and expected with injury, but because cognitive strategies demand that the appraisal of pain be changed (i.e., association) or that attention be refocused away from the pain (i.e., dissociation), the strategies can cause ambiguity in terms of possible danger or further injury (Friedman et al., 1985). It is worthwhile to remind ourselves that pain alerts athletes to potential damage to parts of the body and also sets ultimate limits on the performance of athletes (Gauron & Bowers, 1986).

The strategies in this investigation were designed to be used under the supervision of sports medicine specialists in a sports injury rehabilitation setting. The effectiveness of these strategies in rehabilitation adherence has not been tested. Fisher (1990) postulated that dissociation may be an effective strategy to use when attempting to overcome the negative aspects of rehabilitation (e.g., pain, soreness). He also suggested that it may be appropriate to apply systematic reinforcement so that pain and soreness can come to function as a conditioned positive reinforcer (i.e., a "red badge of courage"). Further research needs to be undertaken to determine whether cognitive strategies are effective in adherence to long term rehabilitation regimens (e.g., post-surgical rehabilitation).

Summary

This investigation found that exercise-induced muscle soreness/damage produced significant strength decrements (as measured by PT, TW, and AP) compared to the baseline measure in Session 1. The cognitive strategies of association and dissociation did not significantly enhance performance, although data illustrate that for most performance variables scores increased while the strategies were utilized in Session 3. No other study has used exercise-induced muscle soreness/damage to investigate pain tolerance levels and performance, and it is possible that these strategies are not as effective with acute, long-lasting pain as they have been shown to be with more traditional methods of pain induction (e.g., cold pressor, ischemic pain).

Ratings of muscle soreness, anxiety level, and pre-perception of performance did not adversely affect performance in Sessions 2 and 3. It was possible that subjects with high anxiety levels may have intensified their ratings of muscle soreness and strength performance prior to being tested in Sessions 2 and 3. However, there were no group differences on the MSS, SAT, and Pre-PPS in Sessions 2 and 3, and this led to the acceptance of the research hypothesis that actual muscle soreness, and not anxiety or pre-perception of performance, will be closely related to the decreased performance scores in Sessions 2 and 3 from Session 1.

ANOVAs revealed that there were no group differences on the MSS, Pre-PPS, and Post-PPS in Session 2. Thus, it was reasonable to assume that groups had a random mix of low and high pain tolerators. This led to the acceptance of the research hypothesis that there will be no group differences on the MSS, Pre-PPS, and Post-PPS in Session 2.

The cognitive strategies of association and dissociation were administered in Session 3. It has already been established that performance did not significantly improve while subjects utilized their strategies. However, ANOVA of the Post-PPS scores in Session 3 revealed that the association and dissociation groups differed significantly from the control group. Thus, while performance was not significantly enhanced, perception of performance was. Illusory efficacy may help to explain this apparent paradox. Subjects believed in the efficacy of the strategies, and their sense of self-efficacy in utilizing the strategies was heightened. They believed that the strategies had worked, were enthusiastic after the test, and all were willing to use their strategies again.

Illusory efficacy appears to be an important personal construct. Taylor (1989) stated that individuals can tolerate extreme levels of distress so long as they believe they have the ability to control that distress. This can be particularly helpful to those with low pain tolerance. In sports injury rehabilitation those with low levels of pain tolerance tend to adhere less to their programs (Fisher, 1990). If these strategies can provide low pain tolerance athletes with a sense of illusory efficacy that then promotes enhanced adherence to their rehabilitation regimens, only positive results can occur. In addition, it is possible that many of the devastating emotions that are associated with a debilitating injury (Weiss & Troxel, 1986) can be lessened by illusory efficacy. If these strategies can provide positive feelings to counter the negative emotions normally associated with injury, they could be very useful in rehabilitation.

However, sports medicine specialists must be wary when contemplating the use of one of these cognitive strategies. Athletes with a high pain tolerance level may actually increase the severity of their injury by utilizing the strategy. It is worthwhile to remember that pain alerts athletes to damage to parts of the body, and pain also sets ultimate limits on the performance of athletes (Gauron & Bowers, 1986). Thus, sports medicine specialists must have a clear understanding of the type of pain tolerance levels their patients have before deciding to incorporate one of these strategies into a rehabilitation regimen.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study examined the effects of association and dissociation on pain tolerance and performance in athletes with exercise-induced muscle soreness/damage. Female (n = 20) and male (n = 14) athletes volunteered to participate in this study. Muscle soreness/damage was induced in the hamstring and quadricep muscle groups on the Biodex System 2 via eccentric knee flexion and extension at a speed of 90 ^{0}/sec. Subsequent data analyses were conducted on a sample size of 30 after 2 females and 2 males reported for Session 2 with no muscle soreness in both muscle groups. Because muscle soreness was necessary in this study, these 4 subjects were excused from further testing.

Intraclass correlation coefficients (R) revealed the internal consistency of the two sets of 10 repetitions and two sets of 40 repetitions. The R values indicated that all scores of each performance variable for the two sets of 10 repetitions but only the scores from the first set of 40 repetitions be used for subsequent data analyses.

Mixed model ANOVAs and post hoc Tukey analyses revealed that there were significant differences (p < .05) in

PT, TW, and AP from Session 1 to Sessions 2 and 3. Analyses of the MSS, SAT, Pre-PPS, and Post-PPS in Session 2 and the MSS, SAT, and Pre-PPS in Session 3 revealed that there were no group differences on these measures. These results led to the acceptance of the research hypothesis that actual muscle soreness, and not anxiety or pre-perception of performance, was closely related to the decreased performance scores in Sessions 2 and 3 from Session 1.

Examination of Figures 1, 4, 7-12 illustrates a trend for both the association and dissociation groups to increase their scores of PT for both muscle groups with 10 and 40 repetitions and for TW and AP of both muscle groups only at 40 repetitions. This would indicate that cognition intervention was marginally successful in increasing performance scores, but not in a statistical sense.

Analysis of the Post-PPS in Session 3 revealed that the association and dissociation groups differed significantly from the control group. These treatment subjects perceived that the strategies had significantly improved their performance when in reality their performance had not significantly improved. This apparent illusion has both positive and negative effects in relation to sports injury rehabilitation. Those athletes with low pain tolerance tend to adhere less to their rehabilitation (Fisher, 1990) and could be greatly helped by these strategies. Should these injured athletes be provided with an enhanced sense of self-efficacy in tolerating pain by these strategies, then the positive feelings that these strategies seem to evoke can only be beneficial. However, athletes with high levels of pain tolerance may increase the severity of their injury while utilizing such strategies because they might ignore the cues their pain could be providing.

Therefore, it appears that association and dissociation is effective in increasing perceptions of performance but only marginally effective at actually increasing performance. Perhaps the acute long-lasting pain that is associated with exercise-induced muscle soreness/damage explains, in part, this paradox. However, the illusory efficacy that these strategies provided is worthy of future research into their application to sports injury rehabilitation.

Conclusions

The results of this study yielded the following conclusions:

1. Athletes' perception of performance is significantly improved by utilizing association or dissociation strategies.

2. Athletes with muscle soreness/damage are not able to overcome the effects of this soreness and significantly enhance their strength performance while utilizing association or dissociation strategies.

3. Athletes' perception of effort and motivation appear to be enhanced by utilizing association or dissociation strategies.

Recommendations

The following recommendations for further study were made after the completion of this investigation:

1. Tests of the effectiveness of cognitive strategies should be undertaken using actual injured athletes as subjects.

2. Tests of the effectiveness of cognitive strategies should be undertaken after injured athletes have been trained in using these strategies.

3. Further investigation into the concept of illusory efficacy, as it relates to sport injury rehabilitation, should be undertaken.

4. Further investigation into the effectiveness of cognitive strategies that address emotional, cognitive, and behavioral components seem advisable.

Appendix A

INFORMED CONSENT FORM

1. **Purpose of the Study:**

This study has been designed to investigate the effectiveness of psychological strategies on pain tolerance and performance while two muscle groups experience muscle soreness.

2. **Benefits of the Study:**

The results from this study can help sport medicine professionals to better understand the power of the mind in overcoming pain. These strategies can be used by any physical therapist and/or athletic trainer in the clinical setting when treating a patient whose progress has been hampered by pain. The strategies do not take a great deal of time to learn.

3. **Subject Participation:**

Amount of time this will take: The time commitment involved with this study will be approximately 45 min the first day and 60 min the second day. The total amount of sessions are three sessions over 2 days.

Tasks and Procedures: On the 1st day of data collection, you will complete the State Anxiety Test which indicates how you feel at the moment you are completing the

subject initials______________

test. You will then be asked to perform several bouts of exercises requiring maximum effort involving the quadricep and hamstring muscle groups. These tests will be performed on the Biodex, a computerized device used to interpret and assess power and strength of muscles. Following that, you will be asked to exert maximal efforts on a Universal squat machine. After the 1st day of testing, you will experience some muscle discomfort and soreness. This is to be expected and should subside within a few days.

On the 2nd day of data collection, you will complete the State Anxiety Test, Muscle Soreness Scale, Pre-Perception of Performance Scale, and your strength and power will be retested on the Biodex. This will enable a comparison to be made to your performance on the 1st day of testing when maximal effort was elicited. You will then complete the Post-Perception of Performance Scale and be asked to return in 3 hr and be retested.

4. **Risks Associated with Participation in this Study:**

This study will cause you to experience muscle soreness. This soreness should only last a few days and should not

subject initials______________

prevent you from carrying out your normal daily activities.

Maximum effort exercises cannot be performed without some small risk of injury. All precautions will be taken to minimize this risk and assure your safety. The Biodex and the Universal squat machine are very safe and effective exercise devices, and exercises will be supervised at all times by the researcher.

Do not use the strategies at any time without the supervision of a qualified health care professional.

In summary, this study involves experimental protocols that are common in exercise research. Hopefully this study will provide information of great interest to sport medicine professionals.

5. **Need more Information?**

If you would like more information about this study or would like to know the results of the study, please feel free to contact Lorette Pen at home (607) 256-4243 or Dr. A. Craig Fisher in his office at Ithaca College (607) 274-3112 or Dr. Gary Sforzo in his office at Ithaca College (607) 274-3359.

subject initials______________

Appendix A (continued)

6. **Withdrawal from the Study:**

Participation in this study is voluntary, and you are free to withdraw at any time. If you have questions about the study, risks, or procedures, I will be happy to answer them before or after you agree to participate in the study. If you choose to withdraw from the study, you will not suffer penalty of any kind.

7. **How Data will be Maintained in Confidence:**

All of the participants in the study will be given a number code that will be used whenever relevant data are analyzed or presented. All data, questionnaire answers, and results will be kept completely confidential.

I have read the above and understand its contents and I agree to participate in the study. I acknowledge that I am 18 years of age or older.

____________________________ __________________

Signature Date

Appendix B

MEDICAL HISTORY QUESTIONNAIRE

Name__________________ Age_____ Birthdate___________

Home Address____

Phone__________________

FAMILY HISTORY - Check if any blood relatives (parents, sister, brother, etc.) had?

Heart Disease	( )	High Cholesterol	( )
High Blood Pressure	( )	Diabetes	( )
Stroke	( )		

Other conditions/comments: ____________________________

____

MEDICAL/HEALTH HISTORY - Check if you have ever had?

Heart Disease/Stroke	( )	Lung Disease	( )
High Blood Pressure	( )	Diabetes	( )
Heart Murmur	( )	High Cholesterol	( )
Skipped, rapid beats, or irregular rhythms	( )	Epilepsy	( )
		Asthma	( )
Bronchial problems	( )		

Injuries to back, knees and/or ankles ( ) Please specify the type of injury: ____________________________

Appendix B (continued)

Other conditions/comments:______________________________

PRESENT SYMPTOMS - Have you recently had/have?

Chest pain	( )	Illness, surgery, or hospitalization	( )
Shortness of breath	( )	Ankle/leg swelling	( )
Lightheadedness	( )	Joint/muscle pain	( )
Heart palpitations	( )	Allergies	( )
Loss of consciousness	( )		

Strained/sore muscles ( ) Please specify where you were/are sore:

____

____

Other conditions/comments :

____

____

LIST ALL MEDICATIONS PRESENTLY TAKEN : ____________

____

____

HEALTH HABITS

1. SMOKING HISTORY

Do you smoke? ( ) ( ) Quit ( ) Never

What do (did) you smoke? ( ) Cigarettes ( ) Cigars

Appendix B (continued)

How much do (did) you smoke a day? ______________________

How long have (had) you been smoking? ____________________

If quit, when?

____

2. EXERCISE HABITS

Do you presently engage in physical activity?( ) Yes ( ) No

What kind?

____

How hard? ( ) Light ( ) Moderate ( ) Hard

How often per week?

____

Do you have any discomfort, shortness of breath, or pain with exercise? ( ) Yes ( ) No

If yes, what type of exercise?

____

3. NUTRITIONAL BEHAVIOR

How many meals do you typically eat per day? _____________

How often do you eat meals outside of home per week? ______

4. STRESS

Do you consider your day stressful? ( ) Yes ( ) No

Appendix B (continued)

What is the nature of your stress?

____

How many hours do you sleep a night?

____

Is your sleep sound? ( ) Yes ( ) No

ADDITIONAL PERTINENT INFORMATION :______________

____

SIGNATURE ____________________ DATE ___________

Appendix C

STATE ANXIETY TEST

Subject Number ____________

Date ________________________

Test/Session Number ______

DIRECTIONS: A number of statements that people have used to describe themselves is given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you <u>feel</u> right now, that is, <u>at this moment</u>. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

1 = Not at all
2 = Somewhat
3 = Moderately so
4 = Very much so

a.	I feel at ease	1	2	3	4
b.	I feel nervous	1	2	3	4
c.	I feel comfortable	1	2	3	4
d.	I am tense	1	2	3	4
e.	I feel secure	1	2	3	4
f.	I feel anxious	1	2	3	4
g.	I am relaxed	1	2	3	4
h.	I am jittery	1	2	3	4
i.	I feel calm	1	2	3	4
j.	I feel over-excited and "rattled"	1	2	3	4

Appendix D

PRE-PERCEPTION OF PERFORMANCE SCALE

Subject Number ________________

Session Number ________________ **Circle one response.**

This testing session, in comparison to my previous testing session, I feel that my strength performance will be :

Much weaker

(<50 %)

Somewhat weaker

(75 %)

Slightly weaker

(90%)

Same

(100 %)

Slightly better

(110 %)

Somewhat better

(125 %)

Much better

(>150 %)

Appendix E

MUSCLE SORENESS SCALE

Subject Number ______________________

Date ________________________________

DIRECTIONS: A number of statements that are used to describe pain are given below. Read each statement and then mark the appropriate circle that best indicates the degree of pain (muscle soreness) you are feeling right now. Be as precise and accurate as you can be. Just indicate as best as you can how sore your quadriceps and hamstring muscle groups feel at this moment.

No pain - mild, barely perceptible symptoms of pain

Vague pain - Dull ache upon palpation

Slight pain - Persistent discomfort, but does not interfere with movement

More than slight pain - Soreness that hampers complex movement (e.g. walking)

Painful - Constant pain and stiffness that interferes with most daily tasks

Very painful - Continual pain without movement

Extremely painful - Severe soreness, intolerable throbbing pain

No pain	Vague pain	Slight pain	More than slight pain	Painful	Very painful	Extremely painful

Appendix F

POST-PERCEPTION OF PERFORMANCE SCALE

Subject Number ______________

Session Number ______________ **Circle one response.**

This testing session, in comparison to my previous testing session, I felt that my strength performance was :

Much weaker

(<50 %)

Somewhat weaker

(75 %)

Slightly weaker

(90%)

Same

(100 %)

Slightly better

(110 %)

Somewhat better

(125 %)

Much better

(>150 %)

Appendix G

STRATEGY EVALUATION QUESTIONNAIRE

Please answer the questions below as accurately as you can. There are no right or wrong answers.

Directions: Circle the response that best describes your answer.

SD = strongly disagree
D = disagree
NS = not sure
A = agree
SA = strongly agree
NA = not applicable

1. The strategy helped me to increase my pain tolerance.

SD D NS A SA NA

2. The strategy helped me to increase my performance.

SD D NS A SA NA

3. With practice, I will be able to further increase my pain tolerance.

SD D NS A SA NA

Appendix G (continued)

4. The strategy was simple to use.

SD	**D**	**NS**	**A**	**SA**	**NA**

5. I am usually a focuser (i.e., association).

SD	**D**	**NS**	**A**	**SA**	**NA**

6. I am usually a distractor (i.e., dissociation).

SD	**D**	**NS**	**A**	**SA**	**NA**

7. My concentration wavered while I tried to use the strategy.

SD	**D**	**NS**	**A**	**SA**	**NA**

8. Calculate what percentage of time during this testing session that you felt you utilized the strategy:

   ________ % (per cent)

9. Briefly describe the thoughts that went through your mind during this testing session.

____

____

____

____

10. Do you think you will use this strategy in the future?

    Yes. Why? No. Why not?

____

____

Appendix H

DEBRIEFING STATEMENT

You have just participated in a study that focused on examining the effects of two psychological strategies designed to increase pain tolerance and performance. You were randomly assigned to one of three groups. These three groups were the control, association, and dissociation groups and all groups listened to a prepared tape.. The tape for the control group had no feedback or advice to increase your effort. The tape for the association group had no feedback but had an association strategy that helped subjects focus on their pain and draw strength from it. This strategy was designed to help you use your pain as a source of strength to increase your effort. The tape for the dissociation group had no feedback but had a dissociation strategy that helped subjects dissociate from the pain and focus on anything but the pain. This strategy is designed to help you focus your attention on a word or phrase or breathing and therefore block out the pain and increase your effort. You may listen to the tapes if you wish.

Do you have any other questions I can answer for you? You are welcome to request a copy of the results at the end of the study.

I greatly appreciate your time and help in this study.

Appendix I

STRATEGY DIALOGUES

ASSOCIATION STRATEGY:

You will be performing a session of exercise that requires a maximal effort. During this session of exercise I want you to concentrate on the area that is sore. Focus all of your attention on this area and feel the intensity of the pain you are experiencing.

I want you to score the intensity of the pain you are feeling using the following criteria:

If there is no pain at all it is a 0.

If the pain is a bone crushing, muscle tearing, can't bear it type of pain give it a score of 100.

I want you to score the intensity of your pain somewhere between 0 and 100.

Now, not everyone can do this. Most people want to run away from their pain and believe that if they do not move, then it will not hurt. But I know that you can do this. I know that you are strong and can work through your pain. You will use your pain as a stimulus, a motivator.

Make this pain come alive for you. Place a frame around the entire area that is sore and separate this area from the

Appendix I (continued)

rest of your body. Once you have framed the area that is in pain, shrink the size of the frame until it surrounds only the very sorest part. Imagine that this small framed area is full of bright light that is actually power. Really focus on transferring this small, concentrated area of pain into power to help you increase your effort. Remember the score you gave your pain and the fact that you can work through your pain. Only a few people are able to do this. You are one of them. Focus on the pain and use the pain as power. A maximum effort is needed with each and every exertion.

In summary, what you need to do during this session of exercise is:

1. Score the intensity of your pain from somewhere between 0 (no pain at all) to 100 (bone crushing, muscle tearing, I can't bear it type of pain).

2. Place a frame around the painful area.

3. Make the frame smaller until it surrounds only the very sorest part. Think of this sorest part as bright light which is actually power.

4. Use this small framed area of pain/power as a stimulus, a motivator.

Appendix I (continued)

5. Know that very few people can work through their pain and I know that you are one of these people.

6. Focus on your pain and use it as power to help you to increase your effort with each exertion.

Appendix I (continued)

<u>**DISSOCIATION STRATEGY:**</u>

You will be performing a session of exercise that require maximal effort. During this session of exercise I want you to focus on a very specific thought and you will repeat this thought with every exertion. The thought should be one that you can draw power from to help you to maximize your effort. You should repeat this thought with every exertion as forcefully as you want, either in your mind or out loud.

This thought may be a word or a phrase. The word you select, for example, may be "explode" or "extend" or "power." If you select the word "explode", you will repeat "explode" with each exertion. So in your mind or out loud, you will repeat:

"Explode! Explode! Explode!"

The phrase you select, for example, may be "Push it" or "Do it" or "Let's go." If you select the phrase "Push it" you will repeat "Push it" with each exertion. So in your mind or out loud, you will repeat:

"Push it! Push it! Push it!"

You might prefer to count numerically with each exertion or to focus on your breathing. If you choose to count, focus on

Appendix I (continued)

the number that corresponds to each exertion. So in your mind or out loud, you will repeat:

1 2 3 4 and so on.

If you choose to focus on your breathing, amplify your inhaling and exhaling. Inhale between exertions and exhale during exertions. So in your mind or out loud, you will breathe in (between exertions) and breathe out (during exertions).

Whatever you choose to focus on, remember that you must exert a maximal effort with each exertion.

In summary, what you need to do during this set of exercise is:

1. Decide whether to select a word or a phrase or to count numbers or to focus on your breathing.
2. Focus all of your attention onto this thought.
3. Repeat this thought as forcefully as you can with each exertion, and
4. Exert maximal effort with each exertion.

Appendix I (continued)

CONTROL DIALOGUE:

You will be performing a session of exercise that requires maximal effort. Remember that you must exert a maximal effort with each exertion.

REFERENCES

Anshel, M. H. (1990). Sport psychology: From theory to practice. Scottsdale, AR: Gorsuch Scarisbrick.

Armstrong, R. B. (1984). Mechanisms of exercise-induced delayed onset muscular soreness: A brief overview. Medicine and Science in Sports and Exercise, 16, 529-538.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.

Bandura, A. (1986). Social foundations of thought and action: A social-cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Barbee, J., & Landis, D. (1984). Reliability of Cybex computer measures (Program Abstract, 1984 American Physical Therapy Association Annual Conference). Physical Therapy, 64, 737.

Bayer, T. L., Baer, P. E., & Early, C. (1991). Situational and psychophysiological factors in psychologically induced pain. Pain, 44, 45-50.

Beecher, H. K. (1956). Relationship of significance of wound to pain experienced. Journal of American Medical Association, 161, 609-1613.

Biodex Corporation. (1988). Multi-joint system manual.

Shirley, NY: Author.

Bogduk, N. (1991, March). The anatomy and physiology of nociception. Australian Association of Musculoskeletal Medicine Bulletin, pp. 14-29, 32-36.

Bowsher, D. (1988). Pain: Management and control in physiotherapy. In P. E. Wells, V. Frampton, & D. Bowsher (Eds.), Pain management in physical therapy (pp. 11-17). Norwalk, CT: Appleton and Lange.

Brena, S. (1972). Pain and religion: A psychophysiological study. Springfield, IL: Thomas.

Bresler, D. (1977). Learning to control pain. New York: Ziff-Davis. (Cassette)

Chapman, C. R. (1980). Pain and perception: Comparison of sensory decision theory and evoked potential methods. In J. J. Bonica (Ed.), Pain (pp. 111-139). New York: Raven Press.

Clarkson, P. M., Nosaka, K., & Braun, B. (1992). Muscle function after exercise-induced muscle damage and rapid adaptation. Medicine and Science in Sports and Exercise, 24, 512-520.

Crossman, J., & Jamieson, J. (1985). Differences in perceptions of seriousness and disrupting effects of athletic injury as viewed by athletes and their trainer.

Perceptual and Motor Skills, 61, 1131-1134.

Dishman R. K., & Gettman, I. R. (1980). Psychobiologic influences on exercise adherence. Journal of Sport Psychology, 2, 295-310.

Dolce, J. J., Doleys, D. M., Raczynski, J. M., Lossie, J., Poole, L., & Smith, M. (1986). The role of self-efficacy expectancies in the prediction of pain tolerance. Pain, 27, 261-272.

Domm, M. A. (1985). Rehabilitation adherence. Unpublished master's thesis, Ithaca College, Ithaca, NY.

Duda, J. L., Smart, A. E., & Tappe, M. K. (1989). Predictors of adherence in the rehabilitation of athletic injuries: An application of personal investment theory. Journal of Sport and Exercise Psychology, 11, 367-381.

Egbert, L. D., Battit, G. E., Welch, C. E., & Bartlett, M. D. (1964). Reduction of postoperative pain by encouragement and instruction of patients. New England Journal of Medicine, 270, 825-827.

Feiring, D. C., Ellenbecker, T. S., & Derscheid, G. L. (1990). Test-retest reliability of the Biodex isokinetic dynamometer. Journal of Orthopaedic and Sports Physical Therapy, 11, 298-300.

Fernandez, E. (1989). Artifact in pain ratings, its implications for test-retest reliability, and correction by a new scaling procedure. Journal of Psychopathology and Behavioral Assessment, 12, 1-15.

Fisher, A. C. (1990). Adherence to sports injury rehabilitation programmes. Sports Medicine, 9, 151-158.

Fisher, A. C., Domm, M. A., & Wuest, D. A. (1988, July). Adherence to sports injury rehabilitation programs. The Physician and Sportmedicine, pp. 47-51, 52.

Fisher, A. C., & Hoisington, L. L. (1993). Injured athletes' attitudes and judgments toward rehabilitation adherence. Journal of Athletic Training, 28, 48-54.

Fisher, A. C., Mullins, S. A., & Frye, P. A. (1992). Athletic trainers' attitudes and judgments of injured athletes' rehabilitation adherence. Journal of Athletic Training, 28, 43-47.

Friedman, H., Thompson, R. B., & Rosen, E. (1985). Perceived threat as a major factor in tolerance for experimentally induced cold-water pain. Journal of Abnormal Psychology, 94, 624-629.

Gauron, E. F., & Bowers, W. A. (1986). Pain control techniques in college-age athletes, Psychological Reports, 59, 1163-1169.

Hotchkiss, D. D. (1981). Cognitive strategies for athletic pain tolerance. Unpublished master's thesis, Ithaca College, Ithaca, NY.

Iten, B. L. (1974). Differences between pain tolerance of male and female athletes. Unpublished master's thesis, Western Illinois University, Macomb.

Kanfer, F. H., & Goldfoot, D. A. (1966). Self-control and tolerance of noxious stimulation. Psychological Reports, 18, 79-85.

Kanfer, F. H., & Seidner, M. L. (1973). Self-control: Factors enhancing tolerance of noxious stimulation. Journal of Personality and Social Psychology, 25, 381-389.

Knuckle, C. (1949). Phasic pain induced by cold. Journal of Applied Psychology, 1, 468-474.

Kraus, J. F., & Conroy, C. (1984). Mortality and morbidity from injuries in sports and recreation. Annual Review of Public Health, 5, 163-192.

Lynch, G. P. (1988). Athletic injuries and the practicing sport psychologist: Practical guidelines for assisting athletes. The Sport Psychologist, 2, 161-167.

McCall, K. D., & Malott, J. M. (1984). Distraction and coping with pain. Psychological Bulletin, 95, 516-533.

McCleary, R. W., & Anderson, J. C. (1992). Test-retest reliability of reciprocal isokinetic knee extension and flexion peak torque measurements. Journal of Athletic Training, 27, 362-365.

Melzack, R. (1973). The puzzle of pain. New York: Basic Books.

Melzack, R. (1980). Psychologic aspects of pain. In J.J. Bonica (Ed.), Pain (pp. 1-26). New York: Raven Press.

Melzack, R., & Dennis, S. G. (1978). Neurophysiological foundations of pain. In R. A. Sternbach (Ed.), The psychology of pain (pp. 143-154). New York: Raven Press.

Meyers, M. C., Bourgeois, A.E., Stewart, S., & LeUnes, A. (1992). Predicting pain response in athletes: Development and assessment of the Sports Inventory for Pain. Journal of Sport and Exercise Psychology, 14, 249-262.

Morgan, W. P. (1978, April). The mind of the marathoner. Psychology Today, pp. 38-40, 43, 45-46, 49.

Morgan, W. P., & Pollock, M. L. (1977). Psychologic characterization of the elite distance runner. Annals of the New York Academy of Sciences, 301, 382-403.

Pedersen, P. (1986). The grief response and injury: A special challenge for athletes and athletic trainers. Athletic Training, JNATA, 21, 312-314.

Pennebaker, J. A., & Lightner, J. M. (1980). Competition of internal and external information in an exercise setting. Journal of Personality and Social Psychology, 39, 165-174.

Pennebaker J. A., & Skelton, J. (1978). Psychological parameters of physical symptoms. Personality and Social Psychology Bulletin, 4, 524-530.

Perrin, D. H. (1986). Reliability of isokinetic measures. Athletic Training, JNATA, 21, 319-321.

Rosnow, R. L., & Rosenthal, R. (1989). Statistical procedures and the justification of knowledge in psychological science. American Psychologist, 44, 1276-1284.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 80, (1, Whole No. 609).

Ryan, E. D. (1976). Perceptual characteristics of vigorous people. In A. C. Fisher (Ed.), Psychology of sport (pp. 432-436). Palo Alto, CA: Mayfield.

Ryan, E. D., & Kovacic, C. R. (1966). Pain tolerance and athletic participation. Perceptual and Motor Skills, 22, 383-390.

Sachs, M. H., & Sachs, M. L. (1981). Psychology of running. Champaign, IL: Human Kinetics.

Scott. V., & Gijsbers, K. (1981). Pain perception in competitive swimmers. British Medical Journal, 283, 91-93.

Smith, L. L. (1991). Acute inflammation: The underlying mechanism in delayed onset muscle soreness? Medicine and Science in Sports and Exercise, 23, 542-551.

Smith, A. M., Scott, S. G., & Wiese, D. M. (1990). The psychological effects of sports injuries coping. Sports Medicine, 9, 352-369.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). Manual for the State-Trait Anxiety Inventory. Palo Alto, CA: Consulting Psychologist Press.

Spink, K. S. (1988). Facilitating endurance performance: The effects of cognitive strategies and analgesic suggestions. The Sport Psychologist, 2, 97-104.

Stevenson, M. K., Kanfer, F. H., & Higgins, J. M. (1984). Effects of goal specificity and time cues on pain tolerance. Cognitive Therapy and Research, 8, 415-426.

Taylor, S. E. (1989). Positive illusions: Creative self-deception and the healthy mind. New York: Basic Books.

Thorn, B. E., & Williams, G. A. (1989). Goal specification alters perceived pain intensity and tolerance latency. Cognitive Therapy and Research, 13, 171-183.

Weinberg, R. S., Gould, D., Yukelson, D., & Jackson, A. (1981). Effect of pre-existing and manipulated self-efficacy on a competitive muscular endurance task. Journal of Sport Psychology, 3, 345-354.

Weinberg, R. S., Jackson, A., & Gould, D. (1979). Expectations and performance: An empirical test of Bandura's self-efficacy theory. Journal of Sport Psychology, 1, 320-331.

Weinberg, R. S., Smith, J., Jackson, A., & Gould, D. (1984). Effect of association, dissociation and positive self-talk strategies on endurance performance. Canadian Journal of Applied Sport Sciences, 9, 25-32.

Weise, D. M., & Weiss, M. R. (1987). Psychological rehabilitation and physical injury: Implications for the sportsmedicine team. The Sport Psychologist, 1, 318-330.

Weiss, M. R., & Troxel, R. K. (1986). Psychology of the injured athlete. Athletic Training, JNATA, 21, 104-110.

Williams, S. L., & Kinney, P. J. (1991). Performance and nonperformance strategies for coping with acute pain: The role of perceived self-efficacy, expected outcomes, and attention. Cognitive Therapy and Research, 15, 1-19.